

Nikola Tesla's 123 Patents

尼古拉·特斯拉
的123个专利



2022年9月5日

PREFACE

前言

Although Nikola Tesla began his inventing work at the beginning of the 1880s, in the period from 1881 to 1882 while he was working for the Central Telegraph Office in Budapest, there is no information of him attempting to obtain a patent for any of his inventions. He applied for his first patent, for an electric arc lamp, after his arrival in the USA on March 30, 1884, immediately after leaving Edison's company and founding his own Tesla Electric Light and Manufacturing. Over the next 43 years, up to 1928, Nikola Tesla protected many of his inventions with patents. The first was US patent no. 334,823 for a commutator for dynamo electric machines and the last US patent no. 1,655,114 for an apparatus for aerial transport. Tesla held a total of 112 registered US patents, while the total of Tesla's patents in other countries has not yet been definitively determined. To date, 196 patents held by Tesla have been identified from another 26 countries, apart from the US. The largest number of these patents (30) were granted in France. Patents were also held in the United Kingdom (29), Belgium (27), Germany (21), Italy (19) and Austria (15) with other countries granting between one and seven patents. Thus Tesla held a total of at least 308 patents from 27 different countries on five continents. However, many of these patents related to the same inventions. The reason for the same invention being protected by several patents in various countries is the limited territory of patents, which means that they are valid only in the state in which they are granted. The collection of patents which protect the same invention in various countries is known as the patent family and these patents are known as equivalent patents. The first patent registered is known as the basic patent.

虽然尼古拉·特斯拉在 19 世纪 80 年代初就开始了他的发明工作，但在 1881 年至 1882 年期间，当他在布达佩斯的中央电报局工作时，没有他试图为他的任何发明获得专利的信息。在他到达美国之后，在 1884 年 3 月 30 日，他离开爱迪生的公司，然后立即申请了他的第一个专利，是关于电弧灯，并创立了自己的特斯拉电灯和制造厂。在接下来的 43 年里，直到 1928 年，尼古拉·特斯拉用专利保护了他的许多发明。第一个是美国专利第 334,823 号，关于发电机的换向器，最后一个美国专利第 1,655,114 号，关于空中运输设备。特斯拉总共拥有 112 项美国注册专利，而特斯拉在其他国家的专利总数尚未确定。迄今为止，特斯拉持有的 196 项专利已被认定来自除美国以外的另外 26 个国家。其中数量最多的专利（30 项）是在法国授予的。英国（29 项）、比利时（27 项）、德国（21 项）、意大利（19 项）和奥地利（15 项）也拥有专利，其他国家授予 1 至 7 项专利。因此，特斯拉总共拥有来自五大洲 27 个不同国家的至少 308 项专利。然而，这些专利中有许多涉及相同的发明。同一项发明在不同国家受到多项专利保护的原因是专利的地域有限，这意味着它们只在被授予专利的国家有效。在不同国家保护同一发明的专利的集合被称为专利族，这些专利被称为等同专利。第一个注册的专利被称为基本专利。

Analysis and comparison of Tesla's patents has established that he was granted 116 basic patents for his inventions, 119 in the US and 7 in the UK, protecting a total of 125 inventions. The remaining 192 patents are equivalents of these basic patents. The inventions that Tesla protected in the largest number of countries were his pump and turbine (US patents 1,061,142 and 1,061,206), for which he was granted 23 patents in 22 countries. In contrast to this, 54 patents granted to Tesla in the US do not have equivalents in other countries. The greatest number of patent applications submitted by Tesla was in

1889, a total of 37 applications relating to his polyphase system.

对特斯拉专利的分析和比较表明，他的发明获得了 116 项基本专利，其中 119 项在美国，7 项在英国，总共保护了 125 项发明。其余 192 项专利是这些基本专利的等同物。特斯拉在最多国家保护的发明是他的泵和涡轮机（美国专利第 1,061,142 号和第 1,061,206 号），他在 22 个国家获得了 23 项专利。与此形成对比的是，特斯拉在美国获得的 54 项专利在其他国家却没有对应的专利。特斯拉在 1889 年提交的专利申请数量最多，共有 37 项申请与他的多相系统有关。

The Archives of the Nikola Tesla Museum hold records of around 33 failed American patent applications, as well as patent applications which Tesla prepared but did not submit. Tesla also created a significant number of inventions for which he did not attempt to secure patent protection, such as the application of high frequency current for medical purposes.

尼古拉·特斯拉博物馆的档案记录了大约 33 项失败的美国专利申请，以及特斯拉准备好但没有提交的专利申请。特斯拉还创造了大量他没有试图获得专利保护的发明，例如将高频电流用于医疗目的。

COMMUTATOR FOR DYNAMO- ELECTRIC MACHINES.

发电机换向器

NIKOLA TESLA, OF SMILJAN LIKA, AUSTRIA-HUNGARY, ASSIGNOR TO THE TESLA
ELECTRIC LIGHT AND MANUFACTURING COMPANY, OF RAHWAY, NEW JERSEY.

奥匈帝国利卡县史密里安村的尼古拉·特斯拉将专利权转让给
新泽西州拉威市的特斯拉电灯与制造公司

SPECIFICATION forming part of Letters Patent No. 334,823, dated January 26, 1886.

Application filed May 6, 1885. Serial No. 164,534. (No model.)

该说明书形成了颁发于 1886 年 1 月 26 日编号为 334,823 的专利证书的一部分。

申请于 1885 年 5 月 6 日提交。序列号为 164,534。(没有模型)

To all whom it may concern:

致所有相关人士:

Be it known that I, NIKOLA TESLA, of Smiljan Lika, border country of Austria-Hungary, have
invented an Improvement in Dynamo-Electric Machines, of which the following is a specification.

众所周知，我、尼古拉·特斯拉、来自奥匈帝国边境地区的利卡县的史密里安村，在发电机
方面已经发明了一个改进，以下是该发明一个说明书。

My invention relates to the commutators on dynamo-electric machines, especially in machines of great
electro-motive force, adapted to arc-lights; and it consists in a device by means of which the sparking
on the commutator is prevented. It is known that in machines of great electro-motive force—such, for
instance, as those used for arc lights—whenever one commutator bar or plate comes out of contact
with the collecting-brush a spark appears on the commutator. This spark may be due to the break of
the complete circuit, or of a shunt of low resistance formed by the brush between two or more
commutators-bars. In the first case the spark is more apparent, as there is at the moment when the
circuit is broken a discharge of the magnets through the field-helices, producing a great spark of flash
which causes an unsteady current, rapid wear of the commutator-bars and brushes, and waste of power.
The sparking may be reduced by various devices, such as providing a path for the current at the moment
when the commutator-segment or bar leaves the brush, by short-circuiting the field-helices, by
increasing the number of the commutator-bars, or by other similar means; but all these devices are
expensive, or not fully available, and seldom attain the object desired.

我的发明涉及发电机上的换向器，特别是在适用于弧光灯的大电动势机器中；并且它包括一
种装置，通过该装置来防止换向器上的火花。众所周知，在电动势很大的机器中，例如用于
产生弧光灯的机器，每当一个换向条或换向板与集电刷脱离接触时，换向器上就会产生火花。
这种火花可能是由于完整电路的断路，或者是由两个或多个换向条之间的电刷形成的低电阻

分流造成的。在第一种情况下，火花更明显，因为在电路断开的瞬间，磁体通过场螺旋放电，产生巨大的闪光火花，这导致不稳定的电流、以及换向器条和电刷的快速磨损，还有功率的浪费。可以通过各种装置来减少火花，例如当换向器分段或换向条离开电刷时通过短路场螺旋、通过增加换向条的数量或通过其它类似的方法来为电流提供通路；但是所有这些设备都很昂贵，或者不是完全可用，并且很少达到预期的目的。

My invention enables me to prevent the sparking in a simple manner. For this purpose I employ with the commutator-bars and intervening insulating material mica, asbestos paper or other insulating and preferably incombustible material, which I arrange to bear on the surface of the commutator, near to and behind the brush.

我的发明使我能够以简单的方式防止火花。为了这个目的，我使用换向条和介入的绝缘材料云母、石棉纸或其他绝缘材料，最好是不可燃材料，我将这些材料布置成倚靠在换向器的表面，靠近电刷或者位于电刷后面。

My invention will be easily understood by reference to the accompanying drawings.

通过参考附图，将容易理解我的发明。

In the drawings, Figure 1 is a section of a commutator with an asbestos insulating device; and Fig. 2 is a similar view, representing two plates of mica upon the back of the brush.

在附图中，图 1 是具有一个石棉绝缘装置的一个换向器的截面图；图 2 是一个类似的视图，代表压在电刷背面的两块云母板。

In Fig. 1, C represents the commutator and intervening insulating material; B B, the brushes. d d are sheets of asbestos material. f f are springs, the pressure of which may be adjusted by means of the screws g g.

在图 1 中，C 代表换向器和介入的绝缘材料；B B 是电刷。d d 是石棉材料的薄片。f f 是弹簧，其压力可以通过螺钉 g g 来调节。

In Fig. 2 a simple arrangement is shown with two plates of mica or other material. It will be seen that whenever one commutator-segment passes out of contact with the brush the formation of the arc will be prevented by the intervening insulating material coming in contact with the insulating material on the brush.

在图 2 中，展示了具有两块云母板或其它材料的简单布置。将会看到，每当一个换向器片脱离与电刷的接触时，电弧的形成将被即将与电刷上的绝缘材料接触的介入的绝缘材料所阻止。

My invention may be carried out in many ways; and I do not limit myself to any particular device, as my invention consists, broadly, in providing a solid non-conducting body to bear upon the surface of the commutator, by the intervention of which body the sparking is partly or completely prevented.

我的发明可以以多种方式实现；并且我不将自己限制于任何特定的装置，因为我的发明广泛地包括提供一种固态非导体来倚靠在换向器的表面上，通过非导体的介入，火花被部分地或完全地防止。

I prefer to use as best us paper or cloth impregnated with zinc-oxide, magnesia, zirconia, or other suitable material, as the paper and cloth are soft, and serve at the same time to wipe and polish the commutator; but mica or any other suitable material may be employed, said material being an insulator or a bad conductor of electricity.

我更喜欢使用浸渍氧化锌、氧化镁、氧化锆或其他合适的材料的最好的美国纸或布，因为纸和布是柔软的，同时用于擦拭和抛光换向器；但是可以使用云母或任何其他合适的材料，所述材料是绝缘体或电的不良导体。

My invention may be applied to any electric apparatus in which sliding-contacts are employed.

我的发明可以应用于任何采用滑动触点的电气设备。

I claim as my invention—

我主张我的发明是—

1. The combination, with the commutator-bars and intervening insulating material and brushes in a dynamo-electric machine, of a solid insulator or bad conductor of electricity arranged to bear upon the surface of the commutator adjacent to the end of the brush, for the purpose set forth.

1、一种固体绝缘体或电的不良导体与发电机中的换向条、介入的绝缘材料和电刷的组合，该固体绝缘体用于倚靠靠近电刷末端的换向器表面，以达到所述目的。

2. In an electric apparatus in which sliding-contacts with intervening insulating material are employed, the combination, with the contact springs or brushes, of a solid insulator or bad conductor of electricity, as and for the purpose set forth.

2、在一种采用了具有介入的绝缘材料的滑动触点的电气设备中，一个固体绝缘体或电的不良导体与接触弹簧或电刷的组合，用于所述目的。

Signed by me this 2nd day of May, A.D. 1885.

本人于公元 1885 年 5 月 2 日签署。

NIKOLA TESLA.

尼古拉·特斯拉

Witnesses:

GEO. T. PINCKNEY,

WILLIAM G. MOTT.

见证人:杰奥·T·平克尼、威廉·G·莫特。

(No Model.)

N. TESLA.

COMMUTATOR FOR DYNAMO ELECTRIC MACHINES.

No. 334,823.

Patented Jan. 26, 1886.

Fig. 1.

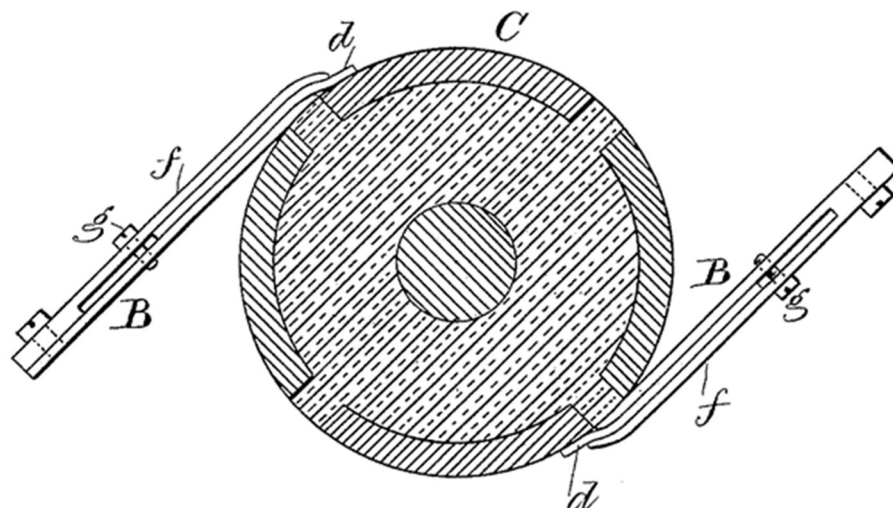
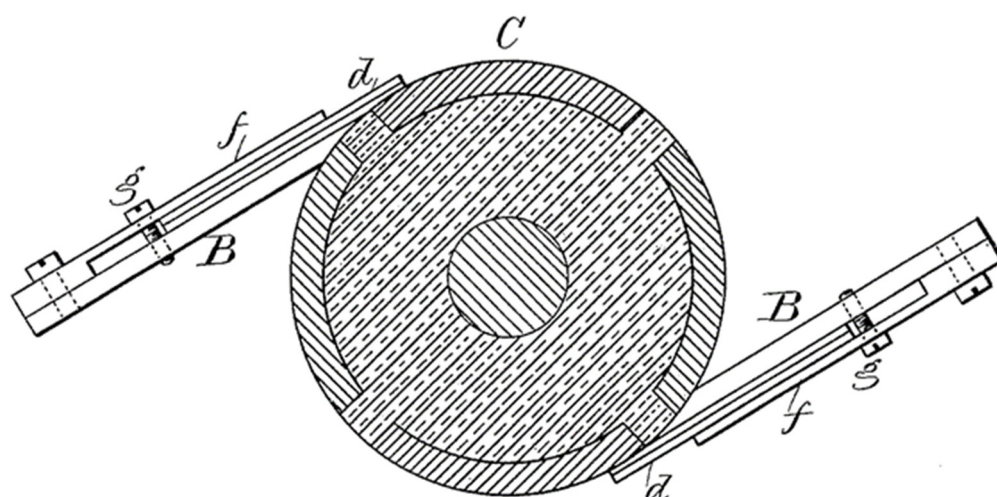


Fig. 2.



Witnesses

Char. H. Smith
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Inventor

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att'y.

REGULATOR FOR DYNAMO-ELECTRIC MACHINES.

用于发电机的调节器

NIKOLA TESLA, OF SMILJAN LIKA, AUSTRIA-HUNGARY, ASSIGNOR TO THE TESLA
ELECTRIC LIGHT AND MANUFACTURING COMPANY, OF RAHWAY, NEW JERSEY.

奥匈帝国利卡县史密里安村的尼古拉·特斯拉将专利权转让给
新泽西州拉威市的特斯拉电灯与制造公司

SPECIFICATION forming part of Letters Patent No. 336,961, dated March 2, 1886.

Application filed May 18, 1885. Serial No. 165,793. (No model.)

该说明书形成了颁发于 1886 年 3 月 2 日编号为 336,961 的专利证书的一部分。

申请于 1885 年 5 月 18 日提交。序列号为 165,793。(没有模型)

To all whom it may concern:

致所有相关人士:

Be it known that I, NIKOLA TESLA, of Smiljan Lika, border country of Austria-Hungary, have
invented an Improvement in Dynamo Electric Machines, of which the following is a specification.

众所周知，我、尼古拉·特斯拉、来自奥匈帝国边境地区的利卡县的史密里安村，在发电机
方面已经发明了一个改进，以下是该发明一个说明书。

The object of my invention is to provide an improved method for regulating the current on dynamo-
electric machines.

我的发明的目的是提供一种用于调节发电机上的电流的改进方法。

In my improvement I make use of two main brushes, to which the ends of the helices of the field-
magnets are connected, and an auxiliary-brush and a branch or shunt connection from an intermediate
point of the field-wire to the auxiliary-brush.

在我的改进中我利用了两个主电刷来连接场磁体螺旋的两个端点，还利用了一个辅助电刷和
从励磁场导线的中间点到该辅助电刷的一个分支或分流连接。

The relative positions of the respective brushes are varied, either automatically or by hand, so that the
shunt becomes inoperative when the auxiliary-brush has a certain position upon the commutator, but
when said auxiliary brush is moved in its relation to the main brushes, or the latter are moved in their
relation to the auxiliary brush, the electric condition is disturbed and more or less of the current through
the field-helices is diverted through the shunt or a current said shunt to the field-helices.

各个电刷的相对位置可以自动或手动改变,使得当辅助电刷在换向器上具有某一位置时,分流器(分流连接)不起作用,但是当所述辅助电刷相对于主电刷被移动时,或者主电刷相对于辅助电刷被移动时,电条件被扰乱,并且通过励磁螺旋的电流或多或少会通过分流器转移,或者有电流越过所述分流器到达励磁螺旋。

By varying the relative position upon the commutator of the respective brushes automatically in proportion to the varying electrical conditions of the working-circuit the current developed can be regulated in proportion to the demands in the working-circuit.

通过与工作电路的变化的电条件成比例地自动改变各个电刷在换向器上的相对位置,所产生的电流可以与工作电路中的需求成比例地调节。

Devices for automatically moving the brushes in dynamo-electric machines are well known, and those made use of in my machine may be of any desired or known character.

发电机中用于自动移动电刷的装置是众所周知的,并且在我的机器中使用的那些装置可以具有任何期望的或已知的特征。

In the drawings, Figure 1 is a diagram illustrating my invention, showing one core of the field-magnets with one helix wound in the same direction throughout. Figs. 2 and 3 are diagrams showing one core of the field-magnets with a portion of the helices wound in opposite directions. Figs. 4 and 5 are diagrams illustrating the electric devices that may be employed for automatically adjusting the brushes, and Fig. 6 is a diagram illustrating the positions of the brushes when the machine is being energized on the start.

在附图中,图1是展出了我的发明的示意图,它展示了场磁体的一个铁芯,该铁芯具有一个自始至终以相同方向缠绕的螺旋。图2和图3是展示了场磁体的一个铁芯的示意图,其中一部分螺旋以相反方向缠绕。图4和图5展示了可用于自动调节电刷的电气装置,图6展示了当机器开始通电时电刷的位置。

a and b are the positive and negative brushes of the main or working-circuit, and c the auxiliary-brush. The working-circuit D extends from the brushes a and b, as usual, and contains electric lamps or other devices, D', either in series or in multiple arc.

a和b是主电路或工作电路的正负电刷,c是辅助电刷。工作电路D通常从电刷a和b延伸,并包含了串联连接或多弧连接(并联)的电灯或其他装置D'。

M M' represent the field-helices, the ends of which are connected to the main-brushes a and b. The branch or shunt -wire c' extends from the auxiliary-brush c to the circuit of the field-helices, and is connected to the same at an intermediate point, X.

M M'代表励磁螺旋,其末端连接到主电刷a和b。分支或分流导线c'从辅助电刷c延伸到励磁螺旋的电路,并在一个中间点X连接到该电路。

H represents the commutator, with the plates of ordinary construction. It is now to be understood that

when the auxiliary brush c occupies such a position upon the commutator that the electric-motive force between the brushes a and c is to the electro-motive force between the brushes c and b as the resistance of the circuit a M c' c A to the resistance of the circuit b M' c' c B, the potentials of the points X and Y will be equal, and no current will flow over the auxiliary brush; but when the brush c occupies a different position the potentials of the points X and Y will be different, and a current will flow over the auxiliary brush to or from the commutator, according to the relative position of the brushes. If, for instance, the commutator-space between the brushes a and c, when the latter is at the neutral point, is diminished, a current will flow from the point Y over the shunt C to the brush b, thus strengthening the current in the part M', and partly neutralizing the current in the part M; but if the space between the brushes a and c is increased, the current will flow over the auxiliary brush in an opposite direction, and the current in M will be strengthened, and in M' partly neutralized.

H 代表换向器，具有普通结构的板。现在可以理解，当辅助电刷 c 在换向器上占据的位置使得电刷 a 和 c 之间的电动势与电刷 c 和 b 之间的电动势之比等于电路 a M c' c A 的电阻与电路 b M' c' c B 的电阻之比时，点 X 和 Y 的电位相等，没有电流流过辅助电刷；但是当电刷 c 占据一个不同的位置时，点 X 和 Y 的电位将不同，并且根据电刷的相对位置，电流将通过辅助电刷流向换向器或从换向器流出。例如，当电刷 c 处于中性点时，如果电刷 a 和 c 之间的换向器空间减小，电流将从 Y 点通过分流器 C 流到电刷 b，从而加强了 M' 部件中的电流，部分中和了 M 部件中的电流；但是如果电刷 a 和 c 之间的空间增加，电流将沿相反方向流过辅助电刷，并且 M 中的电流将被加强，而 M' 中的电流被部分中和。

By combining with the brushes a, b and c any known automatic regulating mechanism the current developed can be regulated in proportion to the demands in the working-circuit.

通过将电刷 a、b 和 c 与任何已知的自动调节机械装置相结合，可以与工作电路中的需求成比例地调节所产生的电流。

The parts M and M' of the field-wire may be wound in the same direction, (In this case they are arranged as shown in Fig. 1; or, the part M may be wound in the opposite direction, as shown in Figs. 2 and 3.)

励磁导线的部件 M 和 M' 可以沿相同的方向缠绕，(在这种情况下，它们如图 1 所示布置；或者，如图 2 和图 3 所示，部件 M 可以沿相反方向缠绕。)

It will be apparent that the respective cores of the field-magnets are subject to the neutralizing or intensifying effects of the current in the shunt through c', and the magnetism of the cores will be partially neutralized or the point of greatest magnetism shifted, so that it will be more or less remote from or approaching to the armature, and hence the aggregate energizing actions of the field magnets on the armature will be correspondingly varied.

显而易见，场磁体的各个铁芯受到流过 c' 的在分流器中的电流的中和效应或增强效应的影响，并且铁芯的磁性将被部分中和或最大磁性点被转移，使得它将或多或少地远离或接近电枢，因此场磁体对电枢的总励磁作用将相应地变化。

In the form indicated in Fig. 1 the regulation is effected by shifting the point of greatest magnetism, and in Figs. 2 and 3 the same effect is produced by the action of the current in the shunt passing through

the neutralizing-helix.

在图 1 所示的形式中，调节是通过转移最大磁性点来实现的，而在图 2 和图 3 中，通过流经中和螺旋的在分流器中的电流的作用产生了相同的效果。

The relative positions of the respective brushes may be varied by moving the auxiliary brush or the brush c may remain quiescent and the core p be connected to the main brush holder A', so as to adjust the brushes a b in their relation to the brush c. If, however, an adjustment is applied to all the brushes, as seen in Fig. 5, the solenoid should be connected to both A and C, so as to move them toward or away from each other.

各个电刷的相对位置可以通过移动辅助电刷来改变，或者电刷 c 可以保持静止，并且铁芯 p 被连接到主电刷夹持器 A' 上，以便相对于电刷 C 来调节电刷 a b。然而，如果对所有电刷进行调节，如图 5 所示，螺线管应该连接到 A 和 C 上，以便使它们彼此靠近或远离。

There are several known devices for giving motion in proportion to an electric current. I have shown the moving cores in Figs. 4 and 5 as convenient devices for obtaining the required extent of motion with very slight changes in the current passing through the helices. It is understood that the adjustment of the main-brushes causes variations in the strength of the current independently of the relative position of said brushes to the auxiliary brush. In all cases the adjustment may be such that no current flows over the auxiliary brush when the dynamo is running with its normal load.

有几种已知的装置可以产生与电流成比例的运动。我已经在图 4 和图 5 中展示了移动中的铁芯，作为用于利用流经螺旋的电流中的非常微小的变化来获得所需运动范围的便利装置。应当理解，主电刷的调节引起电流强度的变化，而与所述电刷相对于辅助刷的位置无关。在所有情况下，可以进行调整，使得当发电机以正常负载运行时，没有电流流过辅助电刷。

In Figs, 4 and 5, A A indicate the main brush holder, carrying the main brushes, and C the auxiliary brush holder, carrying the auxiliary brush. These brush holders are movable in arcs concentric with the center of the commutator shaft. An iron piston, P, of the solenoid S, Fig. 4, is attached to the auxiliary brush holder C. The adjustment is effected by means of a spring and screw or tightener.

在图 4 和 5 中，A A 表示携带主电刷的夹持器，C 表示承载辅助刷的夹持器。这些电刷夹持器可在与换向器轴的轴心同心的圆弧上移动。螺线管 S 的一个铁活塞 P（图 4）连接到辅助电刷夹持器 C 上。调节是通过一个弹簧和螺钉或紧固件来实现的。

In Fig. 5, instead of a solenoid, an iron tube enclosing a coil is shown. The piston of the coil is attached to both brush holders A A and C. When the brushes are moved directly by electrical devices, as shown in Figs. 4 and 5, these are so constructed that the force exerted for adjusting is practically uniform through the whole length of motion.

在图 5 中，展示了包围一个线圈的一个铁管，而不是螺线管。线圈的活塞连接到电刷夹持器 A、A 和 C 上。当电刷直接由电气装置驱动时，如图 4 和 5 所示，这些电气装置的结构使得施加的调节力在整个运动长度上实际上是一致的。

I am aware that auxiliary brushes have been used in connection with the helices of the field-wire; but in these instance the helices received the entire current through the auxiliary brush or brushes, and said brushes could not be taken off without breaking the circuit through the field. These brushes caused, however, a great sparking upon the commutator. In my improvement the auxiliary brush causes very little or no sparking, and can be taken off without breaking the circuit through the field-helices.

我知道辅助电刷已经被用于与励磁导线的螺旋连接;但是在这些情况下,螺旋接受了通过辅助电刷的全部电流,并且所述电刷不能在不切断通过磁场的电路的情况下被取下。然而,这些电刷在换向器上引起了很大的火花。在我的改进中,辅助刷引起很少或者没有火花,并且可以在不破坏经过励磁螺旋的电路的情况下取下。

My improvement has, besides, the advantages to facilitate the self-exciting of the machine in all cases where the resistance of the field-wire is very great comparatively to the resistance of the main circuit at the start—for instance, on arc-light machines. In this case I place the auxiliary brush c near to or in preference in contact with the brush b, as shown in Fig. 6, In this manner the part M' is completely cut out, and as the part M has a considerably smaller resistance than the whole length of the field-wire the machine excites itself, whereupon the auxiliary brush is shifted automatically to its normal position.

除此之外,我的改进还具有在启动时励磁导线的电阻相对于主电路的电阻非常大的所有情况下促进机器自励磁的优点——例如,在电弧照明的机器上。在这种情况下,如图6所示,我将辅助电刷c放置在电刷b附近或者首选与电刷b接触,以这种方式,部件M'被完全切出电路,并且由于部件M具有比励磁导线的整个长度小得多的电阻,所以机器自励磁,于是辅助电刷自动移动到其正常位置。

I claim as my invention—

我主张我的发明是—

The combination, with the commutator having two or more main brushes and an auxiliary brush, of the field-helices having their ends connected to the main brushes, and a branch or shunt connection from an intermediate point of the field-helices to the auxiliary brush, and means for varying the relative position upon the commutator of the respective brushes, substantially as set forth.

存在一个组合,它包括:具有两个或多个主电刷和一个辅助电刷的换向器;两端与主电刷相连的励磁螺旋;从励磁螺旋的中点连接到辅助电刷的一个分支或分流器;以及用于改变各个电刷在换向器上的相对位置的工具,基本如上所述。

Signed by me this 13th day of May, A.D. 1885.

本人于公元1885年5月13日签署。

NIKOLA TESLA.
尼古拉·特斯拉

Witnesses:

GEO. T. PINCKNEY,

WALLACE L. SERRELL.

证人:

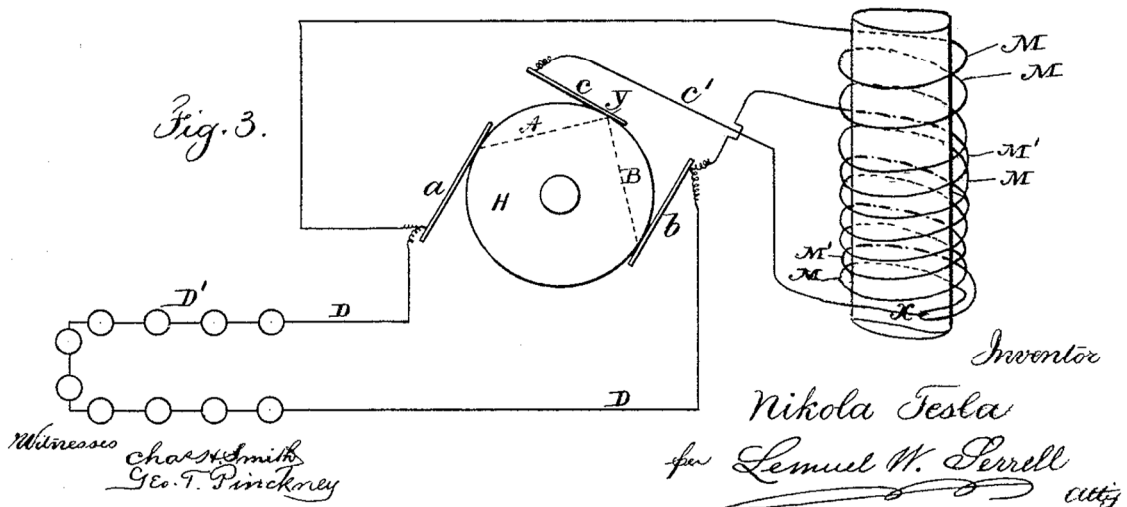
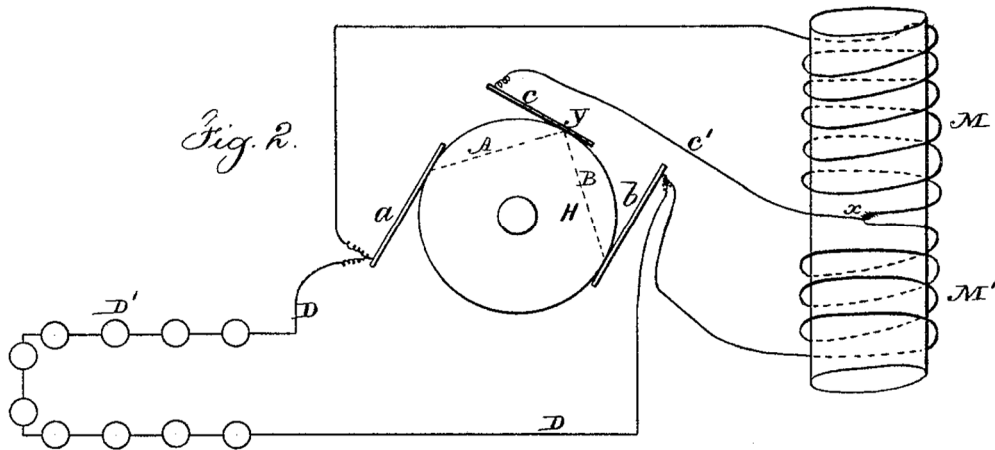
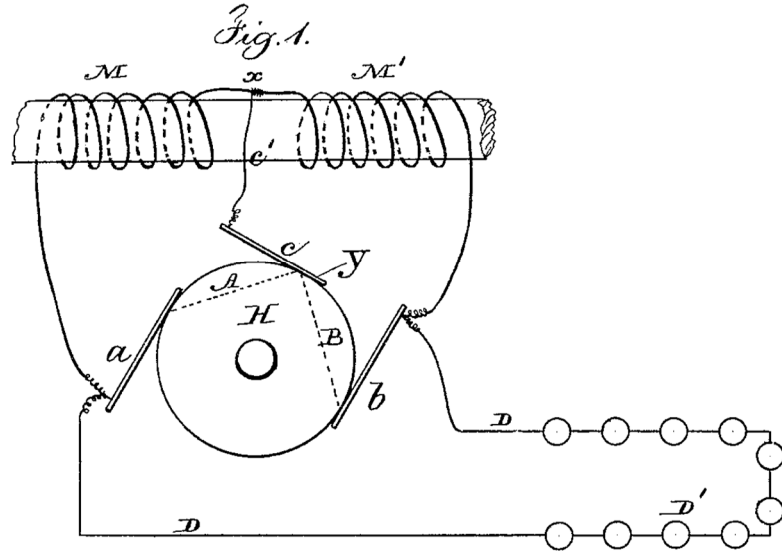
杰奥·T·平克尼、华莱士·塞雷尔。

N. TESLA.

REGULATOR FOR DYNAMO ELECTRIC MACHINES.

No. 336,961.

Patented Mar. 2, 1886.

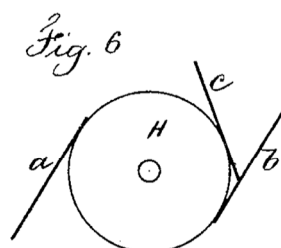
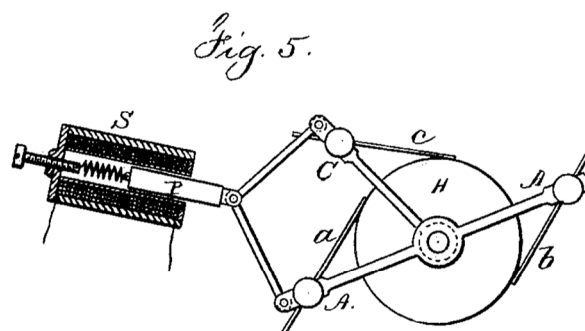
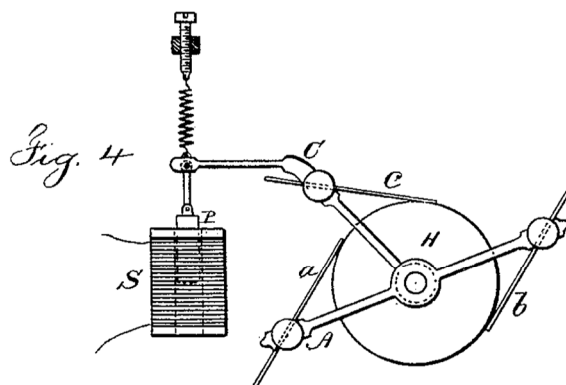


N. TESLA.

REGULATOR FOR DYNAMO ELECTRIC MACHINES.

No. 336,961.

Patented Mar. 2, 1886.



Witnesses

Char. H. Smith
J. Staib

Inventor

Nikola Tesla

per Lemuel W. Serrell

att.

REGULATOR FOR DYNAMO-ELECTRIC MACHINES.

用于发电机的调节器

NIKOLA TESLA, OF SMILJAN LIKA, AUSTRIA-HUNGARY, ASSIGNOR TO THE TESLA
ELECTRIC LIGHT AND MANUFACTURING COMPANY, OF RAHWAY, NEW JERSEY.

奥匈帝国利卡县史密里安村的尼古拉·特斯拉将专利权转让给
新泽西州拉威市的特斯拉电灯与制造公司

SPECIFICATION forming part of Letters Patent No. 336,962 dated March 2, 1886.

Application filed June 1, 1885. Serial No. 167,136. (No model.)

该说明书形成了颁发于 1886 年 3 月 2 日编号为 336,962 的专利证书的一部分。

申请于 1885 年 6 月 1 日提交。序列号为 167,136。(没有模型)

To all whom it may concern:

致所有相关人士:

Be it known that I, NIKOLA TESLA, of Smiljan Lika, border country of Austria-Hungary, have
invented an Improvement in Dynamo Electric Machines, of which the following is a specification.

众所周知，我、尼古拉·特斯拉、来自奥匈帝国边境地区的利卡县的史密里安村，在发电机
方面已经发明了一个改进，以下是该发明一个说明书。

My invention is designed to provide an improved method for regulating the current in dynamo-electric
machines.

我的发明旨在提供一种用于调节发电机中的电流的改进方法。

In another application, No. 165,793, filed by me May 18, 1885, I have shown a method for regulating
the current in a dynamo having the field-helices in a shunt. My present application relates to a dynamo
having its field-helices connected in the main circuit.

在我于 1885 年 5 月 18 日提交的第 165,793 号申请中，我已经展示了一种用于调节在一个发
电机中的电流的方法，该发电机具有在一个分流器中的励磁螺旋。我的本申请涉及一种其励
磁螺旋连接在主电路中的发电机。

In my improvement I employ one or more auxiliary brushes, by means of which I shunt a portion or
the whole of the field-helices. According to the relative position upon the commutator of the respective
brushes more or less current is caused to pass through the helices of the field, and the current developed
by the machine can be varied at will by varying the relative positions of the brushes.

在我的改进中，我使用了一个或多个辅助电刷，通过它们我分流了一部分或整个励磁螺旋。根据各个电刷在换向器上的相对位置，或多或少的电流通过磁场的螺旋，并且通过改变各个电刷的相对位置可以随意改变机器产生的电流。

In the drawings the present invention is illustrated by diagrams, which are hereinafter separately referred to.

在附图中，本发明通过图示来说明，这些图示在下文中单独提及。

In Figure 1, a and b are the positive and negative brushes of the main circuit, and c an auxiliary brush. The main circuit D extends from the brushes a and b, as usual, and contains the helices M of the field-wire and the electric lamps or other working devices. The auxiliary brush c is connected to the point x of the main circuit by means of the wire c'.

在图 1 中，a 和 b 是主电路的正负电刷，c 是一个辅助电刷。主电路 D 通常从电刷 a 和 b 延伸，并包含励磁导线的螺旋 M 和电灯或其他工作装置。辅助电刷 c 通过导线 c' 连接到主电路的 x 点。

H is a commutator of ordinary construction.

H 是一个普通结构的换向器。

From that which has been said in the application above referred to it will be seen that when the electro-motive force between the brushes a and c is to the electro-motive force between the brushes c and b as the resistance of the circuit a M c' c A to the resistance of the circuit b C B c c' D, the potentials of the points x and y will be equal, and no current will pass over the auxiliary brush c; but if said brush occupies a different position relatively to the main brushes the electric condition is disturbed, and current will flow either from y to x or from x to y, according the relative position of the brushes. In the first case the current through the field-helices will be partly neutralized and the magnetism of the field-magnets diminished. In the second case the current will be increased and the magnets will gain strength. By combining with the brushes a b c any automatic regulating mechanism the current developed can be regulated automatically in proportion to the demands in the working-circuit.

从上述申请中可以看出，当电刷 a 和 c 之间的电动势等于电刷 c 和 b 之间的电动势时，电路 a M c' c A 的电阻等于电路 b C B c c' D 的电阻，点 x 和 y 的电位相等，没有电流通过辅助电刷 c；但是如果所述电刷占据了相对于主电刷的一个不同的位置，则电条件被扰乱，并且根据电刷的相对位置，电流将从 y 流向 x 或者从 x 流向 y。在第一种情况下，通过励磁螺旋的电流将被部分中和，场磁体的磁性减弱。在第二种情况下，电流将增加，磁体将获得力量。通过将任何自动调节的机械装置与电刷 a b c 相结合，所产生的电流可以与工作电路中的需求成比例地自动调节。

In Figs. 6 and 7 I have represented some of the automatic means that may be used for moving the brushes. The core P, Fig. 6, of the solenoid-helix S, is connected with the brush c to move the same, and in Fig. 7 the core P is shown as within the helix S, and connected with both brushes a and c, so as to move the same toward or from each other, according to the strength of the current in the helix, the

helix being within an iron tube, S' , that becomes magnetized and increases the action of the solenoid.

在图 6 和 7 中，我已经描述了一些可用于移动电刷的自动装置。螺旋管螺旋 S 的铁芯 P （图 6）与电刷 c 连接，以使其移动，在图 7 中，铁芯 P 显示为在螺旋 S 内，并与电刷 a 和 c 连接，以便根据螺旋中的电流强度使其彼此靠近或远离，螺旋在铁管 S' 内，铁管 S' 被磁化并增强螺旋管的作用。

In practice it is sufficient to move only the auxiliary brush, as shown in Fig. 6, as the regulation is very sensitive to the slightest changes; but the relative position of the auxiliary brush to the main brushes may be varied by moving the main brushes, or both main and auxiliary brushes may be moved, as illustrated in Fig. 7. In the latter two cases, it will be understood, the motion of the main brushes relatively to the neutral line of the machine causes variations in the strength of the current independently of their relative position to the auxiliary brush. In all cases the adjustment may be such that when the machine is running with the ordinary load no current flows over the auxiliary brush.

实际上，只移动辅助电刷就足够了，如图 6 所示，因为调节对最微小的变化都非常敏感；但是辅助电刷与主电刷的相对位置可以通过移动主电刷来改变，或者主电刷和辅助电刷都可以移动，如图 7 所示。可以理解，在后两种情况下，主电刷相对于机器中性线的运动引起电流强度的变化，而这与它们相对于辅助电刷的位置无关。在所有情况下，调整可以是这样的，当机器以普通负载运行时，没有电流流过辅助电刷。

The field-helices may be connected as shown in Fig. 1, or a part of the field-helices may be in the outgoing and the other part in the return circuit, and two auxiliary brushes may be employed as shown in Figs. 3 and 4. Instead of shunting the whole of the field-helices, a portion only of such helices may be shunted, as shown in Figs. 2 and 4.

励磁螺旋可以如图 1 所示连接，或者励磁螺旋的一部分可以在输出电路中，另一部分在返回电路中，并且可以如图 3 和 4 所示使用两个辅助电刷。如图 2 和图 4 所示，可以只分流这些励磁螺旋的一部分，而不是分流整个励磁螺旋。

The arrangement shown in Fig. 4 is advantageous, as it diminishes the sparking upon the commutator, the main circuit being closed through the auxiliary brushes at the moment of the break of the circuit at the main brushes. The field-helices may be wound in the same direction, or part may be wound in opposite directions.

图 4 所示的布置是有利的，因为它减少了换向器上的火花，当电路在主电刷处断开时，主电路通过辅助电刷闭合。励磁螺旋可以沿相同方向缠绕，或者部分励磁螺旋可以沿相反方向缠绕。

The connection between the helices and the auxiliary brush or brushes may be made by a wire of small resistance, or a resistance may be interposed (R , Fig. 5) between the point x and the auxiliary brush or brushes to divide the sensitiveness when the brushes are adjusted.

螺旋和辅助电刷之间的连接可以通过小电阻的导线实现，或者可以在点 x 和辅助电刷之间插入一个电阻（图 5 中的 R ），以在调整电刷时分配灵敏度。

I am aware that it is not new to use auxiliary brushes on the commutator, and that auxiliary brushes have been connected to the field-helices; but I am not aware that the helices of a series dynamo have been shunted by means of auxiliary brushes, and that the relative position of the respective brushes has been varied for the purpose of regulating the current developed by the machine.

我知道在换向器上使用辅助电刷并不新鲜，辅助电刷已经连接到励磁螺旋上；但我不知道一连串的发电机的螺旋已被辅助电刷分流，并且各个电刷的相对位置已经改变，目的是调节由机器产生的电流。

In instances where auxiliary brushes have been used in connection with the field-helices said auxiliary brushes received the current continuously and caused great sparking, whereas in my invention the auxiliary brush receives current only when the normal electrical conditions of the circuit are disturbed.

在辅助电刷与励磁螺旋连接时的情况下，所述辅助电刷接收连续电流并产生大火花，而在我的发明中，辅助电刷仅在电路的正常电条件被扰动时接收电流。

I claim as my invention—

我主张我的发明是—

The combination, with the commutator and main brushes and one or more auxiliary brushes, of the field-helices in the main circuits and one or more shunt-connections from the field-helices to the auxiliary brushes, the relative positions upon the commutator of the respective brushes being adjustable, for the purpose set forth.

存在一个组合，它包括：换向器、主电刷、一个或多个辅助电刷、主电路中的励磁螺旋以及从励磁螺旋到辅助电刷的一个或多个分流连接，各个电刷在换向器上的相对位置是可调节的，用于所述目的。

Signed by me this 16th day of May, A.D. 1885.

本人于公元 1885 年 5 月 16 日签署。

NIKOLA TESLA.

尼古拉·特斯拉

Witnesses:

GEO. T. PINCKNEY,

WALLACE L. SERRELL.

见证人:

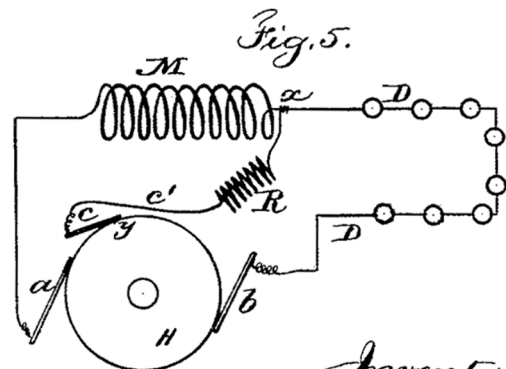
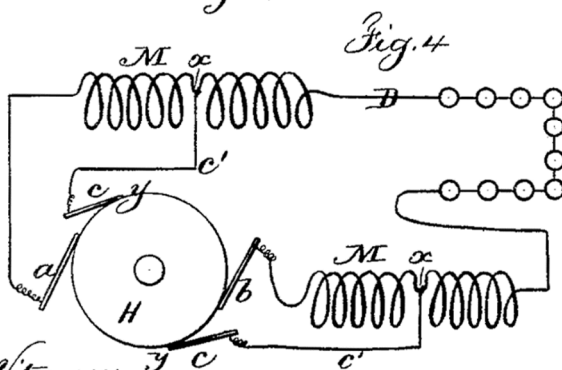
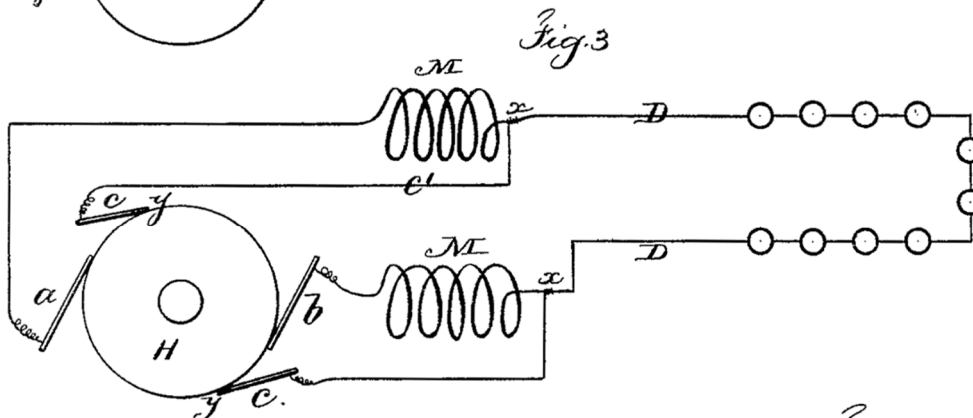
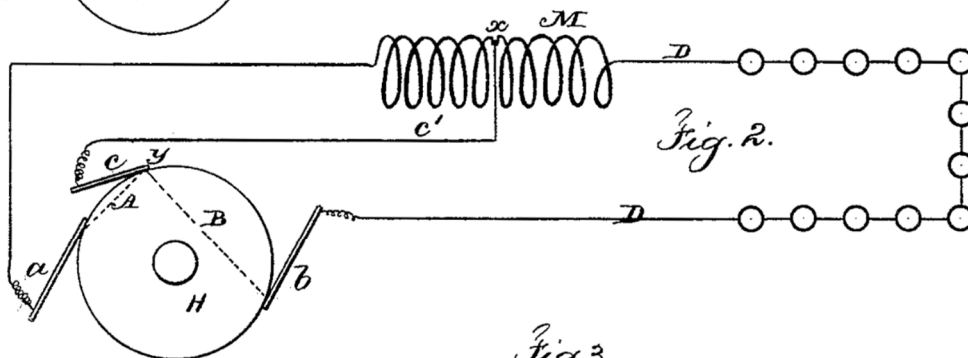
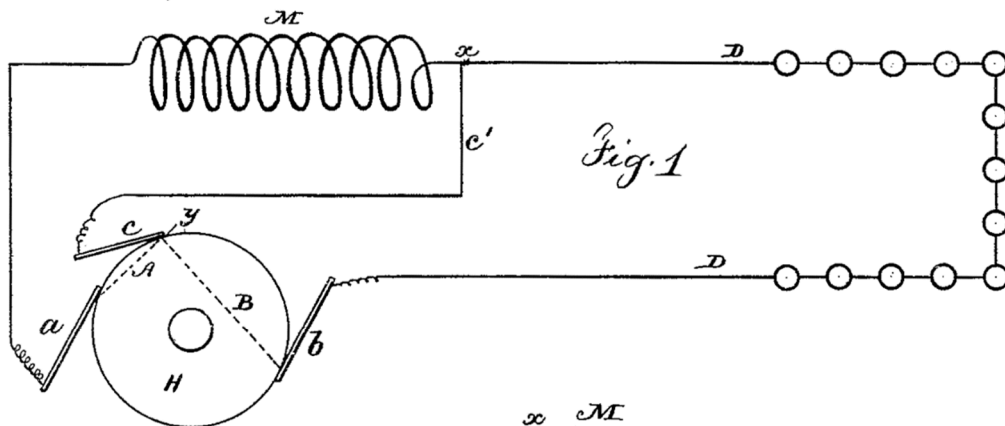
杰奥·T·平克尼、华莱士·塞雷尔。

N. TESLA.

REGULATOR FOR DYNAMO ELECTRIC MACHINES.

No. 336,962.

Patented Mar. 2, 1886.



Witnesses
Chas H Smith
J. Stait

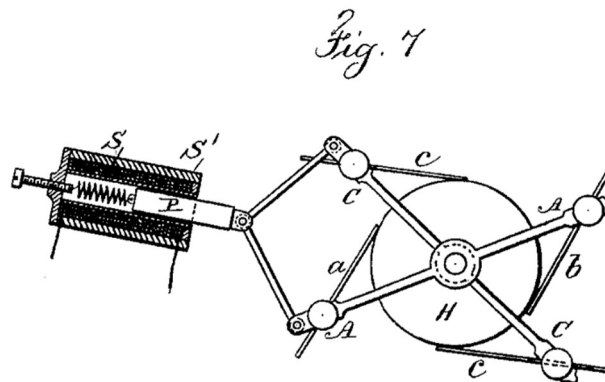
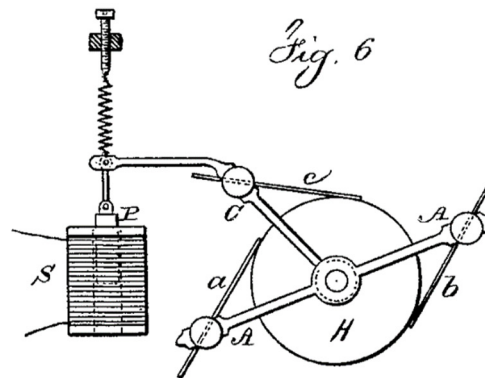
Inventor
Nikola Tesla
per Lemuel W. Serrell atty

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Witnesses

Chas. H. Smith
J. Stair

Inventor

Nikola Tesla
Lemuel W. Perrell

REGULATOR FOR DYNAMO-ELECTRIC MACHINES.

用于发电机的调节器

NIKOLA TESLA, OF SMILJAN LIKA, AUSTRIA-HUNGARY, ASSIGNOR TO THE TESLA
ELECTRIC LIGHT AND MANUFACTURING COMPANY, OF RAHWAY, NEW JERSEY.

奥匈帝国利卡县史密里安村的尼古拉·特斯拉将专利权转让给
新泽西州拉威市的特斯拉电灯与制造公司

SPECIFICATION forming part of Letters Patent No. 350,954 dated October 19, 1886.

Application filed January 14, 1886. Serial No. 188,539. (No model.)

该说明书形成了颁发于 1886 年 10 月 19 日编号为 350,954 的专利证书的一部分。

申请于 1886 年 1 月 14 日提交。序列号为 188,539。(没有模型)

To all whom it may concern:

致所有相关人士:

Be it known that I, NIKOLA TESLA, of Smiljan Lika, border country of Austria-Hungary, have
invented an Improvement in Dynamo-Electric Machines, of which the following is a specification.

众所周知，我、尼古拉·特斯拉、来自奥匈帝国边境地区的利卡县的史密里安村，在发电机
方面已经发明了一个改进，以下是该发明一个说明书。

In another applications I have shown the commutator of a dynamo-machine with the main brushes
connected in an electric circuit, and one or more auxiliary brushes serving to shunt a part or the whole
of the field-coils, the regulation of the current being effected by shifting the respective brushes
automatically upon the commutator in proportion to the varying resistances of the circuit.

在另一个应用中，我已经展示了一个发电机的换向器，该换向器具有连接在一个电路中的主
电刷，以及一个或多个用于分流一部分励磁线圈或者整个励磁线圈的辅助电刷，通过与电路
的电阻变化成比例地在换向器上自动移动相应的电刷来实现电流的调节。

My present invention relates to the mechanical devices which I employ to effect the shifting of the
brushes.

我的本发明涉及我用来实现电刷移动的机械装置。

My invention is clearly shown in the accompanying drawings, in which Figure 1 is an elevation of the
regulator with the frame partly in section; and Fig. 2 is a section at the line x x, Fig. 1.

在附图中清楚地展示了我的发明，其中图 1 是调节器的正视图，其中框架有部分截面图；图 2 是图 1 中的线 x x 处的截面图。

C is the commutator; B and B', the brush-holders, B carrying the main brushes a a' and B' the auxiliary or shunt brushes b b'. The axis of the brush-holder B is supported by two pivot-screws, p p'. The other brush-holder, B', has a sleeve, d, and is movable around the axis of the brush-holder B. In this way both brush-holders can turn very freely, the friction of the parts being reduced to a minimum. Over the brush-holders is mounted the solenoid S, which rests upon a forked column, c. This column also affords a support for the pivots p p', and is fastened upon a solid bracket or projection, P, which extends from the base of the machine, and is preferably cast in one piece with the same. The brush-holders B B' are connected by means of the links e e' and the cross-piece F to the iron core I, which slides freely in the tube T of the solenoid. The iron core I has a screw, s, by means of which it can be raised and adjusted in its position relatively to the solenoid, so that the pull exerted upon it by the solenoid is practically uniform through the whole length of motion which is required to effect the regulation. In order to effect the adjustment with a greater precision the core I is provided with a small iron screw, s'. The core being first brought very nearly in the required position relatively to the solenoid by means of the screw s, the small screw s' is then adjusted until the magnetic attraction upon the core is the same when the core is in any position. A convenient stop, t, serves to limit the upward movement of the iron core.

C 是换向器；B B' 是电刷夹持器，B 携带主电刷 a a'，B' 携带辅助电刷或分流电刷 b b'。电刷夹持器 B 的轴由两个枢轴螺钉 p p' 支撑。另一个电刷架 B' 有一个套筒 d，并可绕电刷架 B 的轴线移动。通过这种方式，两个夹持器都可以非常自由地转动，零件之间的摩擦被降低到最小。在电刷电刷架上安装了螺线管 S，它位于一个叉形柱 c 上。该柱还为枢轴 p p' 提供支撑，并固定在从机器底座延伸的实心支架或突起 P 上，并且最好与后者铸造成一体。电刷夹持器 B B' 通过连杆 e e' 和十字架 F 连接到铁芯 I 上，铁芯 I 在螺线管的管 T 中自由滑动。铁芯 I 有一个螺钉 s，通过它可以相对于螺线管升高和调整铁芯 I 的位置，因此螺线管施加在铁芯 I 上面的拉力在实现调节所需的整个运动长度上实际上是一致的。为了以更高的精度实现调节，铁芯 I 配有一个小的铁螺钉 s'。首先通过螺钉 s 将铁芯带到相对于螺线管非常接近的所需位置，然后调节小螺钉 s'，直到铁芯处于任何位置时施加在铁芯上的磁引力都相同。一个方便的挡块 t 用来限制铁芯的向上运动。

To check somewhat the movement of the core I, a dash-pot, K, is used. The piston L of the dash-pot is provided with a valve, V, which opens by a downward pressure and allows an easy downward movement of the iron core I, but closes and checks the movement of the core when the same is pulled up under the action of the solenoid.

为了检查铁芯 I 的运动，使用了一个减震器 K。减震器的活塞 L 配有阀 V，该阀通过向下的压力打开，并允许铁芯 I 容易地向下运动，但是当铁芯在螺线管的作用下被向上拉动时，该阀关闭并阻止铁芯的运动。

To balance the opposing forces, the weight of the moving parts, and the pull exerted by the solenoid upon the iron core, the weights W W may be used. The adjustment is such that when the solenoid is traversed by the normal current it is just strong enough to balance the downward pull of the parts.

为了平衡相反的不同力、移动部件的重量以及螺线管施加在铁芯上的拉力，可以使用重物 W

W。调整是这样的，当螺线管通过正常电流时，其强度刚好足以平衡零件的向下拉力。

The electrical circuit-connections are substantially the same, as indicated in my former applications, the solenoid being in series with the circuit when the translating devices are in series and in a shunt when the devices are in multiple arc.

电路连接基本上是相同的，如我以前的申请中所指出的，当转换装置串联时，螺线管与电路串联，而当转换装置处于多弧连接时（类似并联），螺线管处在一个分流器中。

The operation of the devices is as follows:

设备的运行如下:

When upon a decrease of the resistance of the circuit or some other reason the current is increased, the solenoid S gains in strength and pulls up the iron core I, thus shifting the main brushes in the direction of rotation and the auxiliary brushes in the opposite way. This diminishes the strength of the current until the opposing forces are balanced and the solenoid is traversed by the normal current; but if from any cause the current in the circuit is diminished, then the weight of the moving parts overcomes the pull of the solenoid, the iron core I descends, thus shifting the brushes the opposite way and increasing the current to the normal strength. The dash-pot connected to the iron core I may be of ordinary construction; but I prefer, especially in machines for arc light, to provide the piston of the dash-pot with a valve, as indicated in the drawings. This valve permits a comparatively easy downward movement of the iron core, but checks its movement when it is drawn up by the solenoid. Such an arrangement has the advantage that a great number of lights may be put on without diminishing the light-power of the lamps in the circuit, as the brushes assume at once the proper position. When lights are cut out, the dash-pot acts to retard the movement; but if the current is considerably increased the solenoid gets abnormally strong and the brushes are shifted instantly.

当电路电阻减小或其它原因导致电流增加时，螺线管 S 的强度增加并向上拉动铁芯 I，从而使主电刷沿旋转方向移动，而辅助电刷沿相反方向移动。这减小了电流的强度，直到相反的不同力被平衡，并且正常电流穿过螺线管；但是，如果由于任何原因，电路中的电流减少，那么移动部件的重量克服了螺线管的拉力，铁芯 I 下降，从而将各电刷向相反的方向移动，并将电流增加到正常强度。与铁芯 I 连接的减震器可以是普通结构；但我更喜欢为减震器的活塞提供一个阀门，尤其是在弧光灯的机器中，如图所示。该阀允许铁芯相对容易地向下移动，但当它被螺线管向上拉动时，会阻止铁芯的移动。这种布置的优点在于，可以点亮大量的灯，而不会降低电路中灯的光功率，因为电刷立刻处于正确的位置。当灯光熄灭时，减震器起着阻滞运动的作用；但是如果电流显著增加，螺线管变得异常强，电刷会立即移动。

The regulator being properly adjusted, lights or other devices may be put on or out with scarcely any perceptible difference.

调节器被适当地调节，灯或其他装置可以被打开或关闭，几乎没有任何可察觉的差异。

It is obvious that instead of the dash-pot any other retarding device may be used.

显然，可以使用任何其它减速装置来代替缓冲器。

I claim as my invention—

我主张这是我的发明—

1. The combination, with the main and auxiliary brushes, of two brush-holders, an axis fastened to one of the brush-holders, supporting screws for the same, a support for the other brush-holder surrounding the axis, a solenoid, a core for the same, and links connecting the core to the respective brush-holders, substantially as set forth.

1、存在一个组合，它包括：主电刷和辅助电刷；两个电刷夹持器；一个轴，它被紧固到其中的一个电刷夹持器；用于该夹持器的支撑螺钉；用于围绕该轴的另一个夹持器的支撑件；一个螺线管；用于该螺线管的铁芯；以及将铁芯连接到各个夹持器的连杆，基本上如前所述。

2. The combination, with the brushes, brush-holders, and the axis upon which the brush-holders swing, of a solenoid and core, connections from the same to the brush-holders, and an adjusting screw to limit the movements of the core, substantially as set forth.

2、存在一个组合，它包括：电刷、电刷夹持器、电刷夹持器摆动所围绕的轴、一个螺线管和铁芯、从铁芯到电刷夹持器的连接、限制铁芯运动的一个调节螺钉，基本如前所述。

3. The combination, with the brush-holders and their axes, of a solenoid and core, and a connection from the core to the brush-holders, and an iron screw at the inner end of the core to adjust the action of the magnetism on the core, substantially as set forth.

3、存在一个组合，它包括：电刷夹持器和它们的轴、一个螺线管和一个铁芯、从铁芯到电刷夹持器的一个连接、在铁芯内端的一个铁螺钉，用于调整施加在铁芯上的磁作用，基本如上所述。

4. The combination, with the brushes, the brush-holders and their axes, of a solenoid and core, and connections to move the brush-holders, and a dash-pot provided with a valve, substantially as described, to diminish the speed of the movement of the core in one direction more than the other, substantially as set forth.

4、存在一个组合，它包括：电刷夹持器和它们的轴、一个螺线管和一个铁芯、用来移动电刷夹持器的连接、配有一个减震器的一个阀门，基本如所述，该减震器用来在一个方向上比在另一个方向上更大程度地减小铁芯的移动速度，基本如上所述。

5. The combination, with the brushes, the brush-holders and their axes, of a solenoid and core, and connections to move the brush-holders, and a dash-pot to diminish the speed of the movement of the core, substantially as set forth.

5、存在一个组合，它包括：电刷夹持器和它们的轴、一个螺线管和一个铁芯、用来移动电刷夹持器的连接、配有一个减震器的一个阀门，基本如所述，该减震器用来在一个方向上比

在另一个方向上更大程度地减小铁芯的移动速度，基本如上所述。

6. The combination, with the brush-holders and the solenoid and core, of links connecting to the holders, and a screw to adjust the position of the core in relation to the solenoid, substantially as set forth.

6、存在一个组合，它包括：电刷夹持器和螺线管和铁芯、连接到夹持器上的连杆，以及调节铁芯相对于螺线管位置的一个螺钉，基本如上所述。

Signed by me this 12th day of January, A.D. 1886.

本人于公元 1886 年 1 月 12 日签署。

NIKOLA TESLA.

尼古拉·特斯拉

Witnesses:

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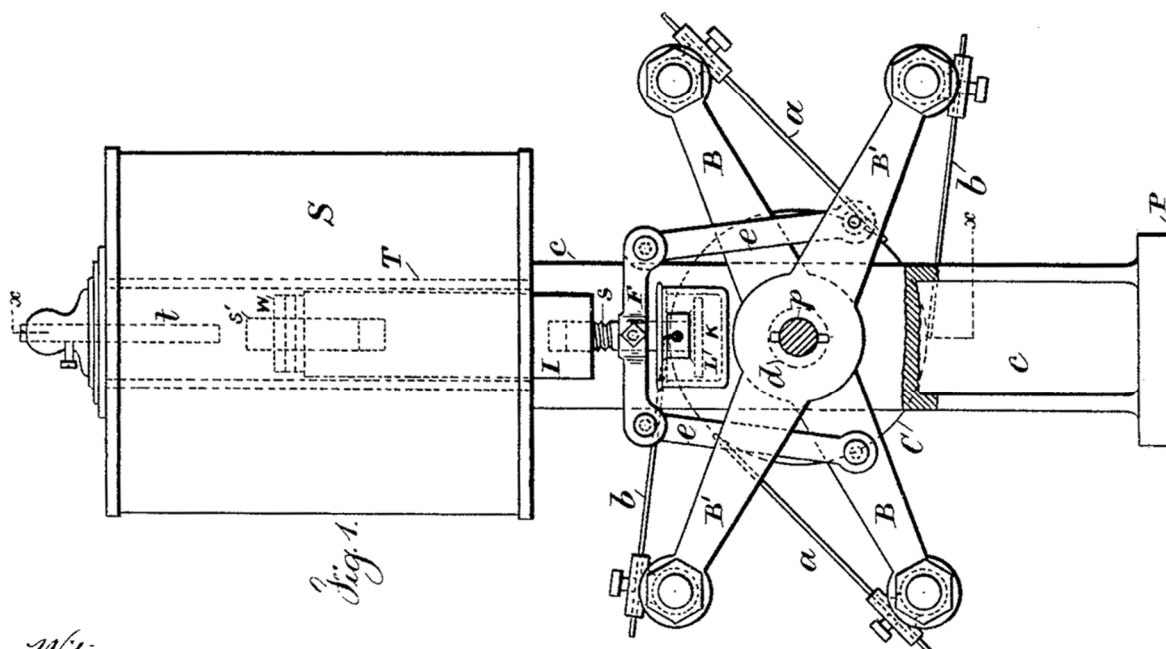
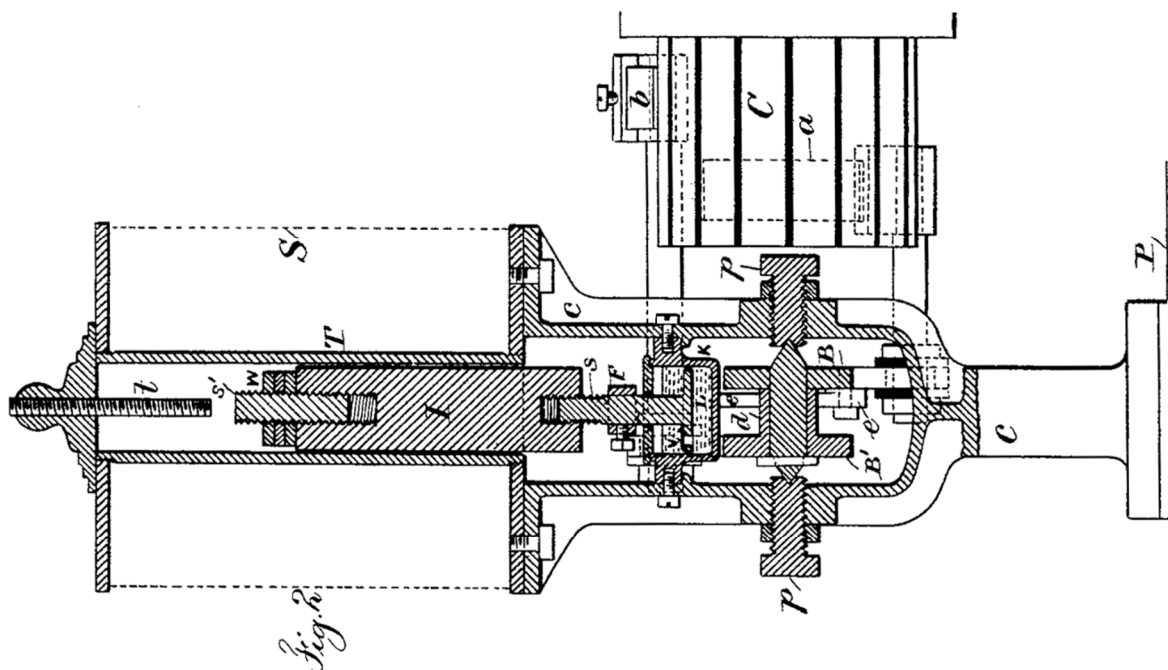
(No Model.)

N. TESLA.

REGULATOR FOR DYNAMO ELECTRIC MACHINES.

No. 350,954.

Patented Oct. 19, 1886.



Witnesses

Char H. Smith
J. Stail

Inventor

Nikola Tesla.
per Lemuel W. Serrell att.

DYNAMO-ELECTRIC MACHINE.

发电机

NIKOLA TESLA, OF SMILJAN LIKA, AUSTRIA-HUNGARY, ASSIGNOR TO THE TESLA
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奥匈帝国利卡县史密里安村的尼古拉·特斯拉将专利权转让给
新泽西州拉威市的特斯拉电灯与制造公司

SPECIFICATION forming part of Letters Patent No. 359,748, dated March 22, 1887.

Application filed January 14, 1886. Renewed December 1, 1886. Serial No. 220,370. (No model.)

该说明书形成了颁发于 1887 年 3 月 22 日编号为 359,748 的专利证书的一部分。

申请于 1886 年 1 月 14 日提交。于 1886 年 12 月 1 日更新。序列号为 220,370。(没有模型)

To all whom it may concern:

致所有相关人员:

Be it known that I, NIKOLA TESLA, of Smiljan Lika, border country of Austria-Hungary, have
invented an Improvement in Dynamo-Electric Machines, of which the following is a specification.

众所周知,我、尼古拉·特斯拉、来自奥匈帝国边境地区的利卡县的史密里安村,在发电机
方面已经发明了一个改进,以下是该发明一个说明书。

The main objects of my invention are to increase the efficiency of the machine and to facilitate and
cheapen the construction of the same; and to this end my invention relates to the magnetic frame and
the armature, and to other features of construction, hereinafter more fully explained.

我的发明的主要目的是提高机器的效率,并且便于建造和降低成本;为此,我的发明涉及磁
性框架和电枢,以及其它结构特征,在下文中将更全面地解释。

My invention is illustrated in the accompanying drawings, in which Figure 1 is a longitudinal section,
and Fig. 2 a cross-section, of the machine. Fig. 3 is a top view, and Fig. 4 a side view, of the magnetic
frame. Fig. 5 is an end view of the commutator-bars, and Fig. 6 is a section of the shaft and commutator-
bars. Fig. 7 is a diagram illustrating the coils of the armature and the connections to the commutator-
plates.

我的发明在附图中展示,其中图 1 是机器的纵向截面图,图 2 是机器的横向截面图。图 3 是
磁性框架的顶视图,图 4 是磁性框架的侧视图。图 5 是换向条的端视图,图 6 是轴和换向条
的截面图。图 7 是展示出电枢的线圈和与换向板的连接的示意图。

The cores c c c c of the field-magnets may be tapering in both directions, as shown, for the purposes
of concentrating the magnetism upon the middle of the pole-pieces.

如图所示，场磁体的铁芯 c c c c 可以在两个方向上逐渐变细，以便将磁性集中在极靴的中间。

The connecting-frame F F of the field-magnets is in the form indicated in the side view, Fig. 4, the lower part being provided with the spreading curved cast legs e e, so that the machine will rest firmly upon two base-bars, r r.

场磁体的连接框架 F F 是图 4 的侧视图所示的形式，下部设有展开的弯曲铸件支腿 e e，使得机器被稳固地放置在两个基柱 r r 上。

To the lower pole, S, of the field-magnet M is fastened, preferably by means of Babbitt or other fusible diamagnetic material, the base B, which is provided with bearings b for the armature-shaft H. The base B has a projection, P, which supports the brush-holders and regulating devices, which may be such as shown in an application of like date herewith.

优选地通过巴氏合金或其它可熔抗磁性材料将底座 B 固定到场磁体 M 的下磁极 S 上，底座 B 配有用于电枢轴 H 的轴承 b。底座 B 具有支撑电刷架和调节装置的一个突出部 P，该突出部可以是如同与本申请同日提交的申请中所示的那样。

The armature is constructed with the view to reduce to a minimum the loss of power due to the transversal or Foucault currents and to the change of polarity, and also to shorten as much as possible the length of the inactive wire wound upon the armature-core.

电枢的构造旨在将横向电流或涡电流以及极性变化造成的功率损耗降至最低，并尽可能缩短缠绕在电枢铁芯上的无效导线的长度。

It is well known that when the armature is revolved between the poles of the field-magnets currents are generated in the iron body of the armature which develop heat, and consequently cause a waste of power. Owing to the mutual action of the lines of force, the magnetic properties of iron, and the speed of the different portions of the armature-core, these currents are generated principally on and near the surface of the armature-core, diminishing in strength gradually toward the center of the core. Their quantity is under same conditions proportional to the length of the iron body in the direction in which these currents are generated. By subdividing the iron core electrically in this direction the generation of these currents can be reduced to a great extent. For instance, if the length of the armature-core is twelve inches, and by a suitable construction the same is subdivided electrically, so that there are in the generating direction six inches of iron and six inches of intervening air-spaces or insulating material, the currents will be reduced to fifty percent.

众所周知，当电枢在场磁体磁极之间旋转时，电枢的铁体内会产生电流，从而产生热量，并因此导致功率浪费。由于磁力线、铁的磁性和电枢铁芯不同部分的速度的相互作用，这些电流主要在电枢铁芯的表面上和表面附近产生，其强度朝着铁芯的中心逐渐减小。在相同的条件下，它们的量与产生这些电流的方向上的铁的长度成正比。通过在这个方向上对铁芯进行电气细分，可以在很大程度上减少这些电流的产生。例如，如果电枢铁芯的长度是 12 英寸，通过一个适当的结构该铁芯被电气细分，所以在发电方向有 6 英寸的铁和 6 英寸的介入的空气空间或绝缘材料，电流将减少到百分之五十。

As shown in the drawings, the armature is constructed of thin iron disks D D D, of various diameters, fastened upon the armature-shaft in a suitable manner and arranged according to their sizes, so that a series of iron bodies, i i i, is formed, each of which diminishes in thickness from the center toward the periphery. At both ends of the armature the inwardly-curved disks d d, preferably of cast-iron, are fastened to the armature-shaft.

如图所示，电枢由不同直径的薄铁盘 D D D 构成，该铁盘以一个合适的方式固定在电枢轴上，并根据它们的尺寸排列，从而形成一系列铁体 i i i，每个铁体的厚度从中心向外周减小。在电枢的两端，向内弯曲的圆盘 d d，最好是铸铁制成，被固定在电枢轴上。

The armature-core being constructed as shown, it will be easily seen that on those portions of the armature that are the most remote from the axis, and where the currents are principally developed, the length of iron in the generating direction is only a small fraction of the total length of the armature-core, and besides this the iron body is subdivided in the generating direction, and therefore the Foucault currents are greatly reduced. Another cause of heating is the shifting of the poles of the armature-core. In consequence of the subdivision of the iron in the armature and the increased surface for radiation the risk of heating is lessened.

电枢铁芯的结构如图所示，很容易看出，在电枢的离轴最远的那些部分上，电流主要在那里产生，铁在发电方向上的长度只是电枢铁芯总长度的一小部分，除此之外，铁体在发电方向上被细分，因此涡电流大大减少。发热的另一个原因是电枢铁芯磁极的移动。由于电枢中的铁的细分和用于辐射的表面的增加，发热的风险减少了。

The iron disks D D D may be insulated or coated with some insulating-paint, a very careful insulation being unnecessary, as an electrical contact between several disks can only occur on places where the generated currents are comparatively weak. An armature-core constructed in the manner described may be revolved between the poles of the field-magnets without showing the slightest increase of temperature.

铁盘 D D D 可以绝缘或涂覆绝缘漆，非常仔细的绝缘是不必要的，因为几个铁盘之间的电接触只能发生在产生的电流相对较弱的地方。以所述方式构造的电枢铁芯可以在场磁体的磁极之间旋转，而不会显示出温度的丝毫增加。

The end disks, d d, which are of sufficient thickness and, for the sake of cheapness, preferably of cast-iron, are curved inwardly, as indicated in the drawings. The extent of the curve is dependent on the amount of wire to be wound upon the armatures. In my present invention the wire is wound upon the armature in two superimposed parts, and the curve of the end disks, d d, is so calculated that the first part—that is, practically half of the wire—just fills up the hollow space to the line x x; or, if the wire is wound in any other manner, the curve is such that when the whole of the wire is wound the outside mass of wires, w, and the inside mass of wires, w', are equal at each side of the plane x x. In this case it will be seen the passive or electrically-inactive wires are of the smallest length practicable. The arrangement has further the advantage that the total lengths of the crossing wires at the two sides of the plane x x are practically equal.

如图所示，端部盘 d d 具有足够的厚度，并且为了便宜起见，最好由铸铁制成，并向内弯曲。

该弯曲曲线的范围取决于缠绕在电枢上的导线数量。在我的本发明中，导线以两个叠加部件缠绕在电枢上，并且端盘的曲线 dd 是这样计算的，使得第一部分——即，实际上是导线的一半——刚好填满线路 xx 的中空空间；或者，如果导线以任何其他方式缠绕，则曲线是这样的，当整个导线缠绕时，导线的外部质量 w 和导线的内部质量 w' 在平面 xx 的每一侧相等。在这种情况下，可以看出无效导线或无电导线具有最小的实际长度。这种布置还具有这样的优点，即在 xx 平面两侧的交叉导线的总长度实际上相等。

To further equalize the armature-coils at both sides of the plates that are in contact with the brushes, the winding and connecting up is effected in the following manner: The whole wire is wound upon the armature-core in two superimposed parts, which are thoroughly insulated from each other. Each of these two parts is composed of three separated groups of coils. The first group of coils of the first part of wire being wound and connected to the commutator-bars in the usual manner, this group is insulated and the second group wound; but the coils of this second group instead of being connected to the next following commutator-bars, are connected to the directly opposite bars of the commutator. The second group is then insulated and the third group wound, the coils of this group being connected to those bars to which they would be connected in the usual way. The wires are then thoroughly insulated and the second part of wire wound and connected in the same manner. Suppose, for instance, that there are twenty-four coils—that is, twelve in each part—and consequently twenty-four commutator-plates. There will be in each part three groups, each containing four coils, and the coils will be connected as follows:

为了进一步平衡与电刷接触的板两侧的电枢线圈，以下列方式进行缠绕和连接：整根电线分两个重叠部分缠绕在电枢铁芯上，这两部分完全绝缘。这两个部分都由三组独立的线圈组成。第一部分导线的第一组线圈以通常的方式缠绕并连接到换向条上，该组线圈被绝缘，然后缠绕第二组线圈；但是第二组线圈不是连接到下一个换向条上，而是连接到换向器的直接径向相对的换向条上。然后第二组被绝缘，然后缠绕第三组线圈，该组的线圈被连接到它们将以通常方式连接的那些条上。然后将导线完全绝缘，并以同样的方式缠绕和连接导线的第二部分。例如，假设有二十四个线圈——也就是说，每个部分有十二个——因此有二十四个换向板。每个部分有三组，每组包含四个线圈，线圈连接如下：

	Groups	Commutator-bars
First part of wire	First.....	1-5
	Second.....	17-21
	Third.....	9-13

	Groups	Commutator-bars
Second part of wire	First.....	13-17
	Second.....	5-9
	Third.....	21-1

	组	换向条
导线第一部分	第一.....	1-5
	第二.....	17-21
	第三.....	9-13

	组	换向条
导线第二部分	第一.....	13-17
	第二.....	5-9
	第三.....	21-1

In constructing the armature-core and winding and connecting the coils in the manner indicated, the passive or electrically-inactive wire is reduced to a minimum, and the coils at each side of the plates that are in contact with the brushes are practically equal, and in this way the electrical efficiency of the machine is increased.

在以所示方式构造电枢铁芯、缠绕和连接线圈的过程中,无效导线或无电导线被减少到最小,并且与电刷接触的板的每一侧的线圈实际上是相等的,并且以这种方式提高了电动的电效率。

The commutator-plates t are shown as outside the bearing b of the armature-shaft. The shaft H is tubular and split at the end portion and the wires are carried through the same in any usual manner and connected to the respective commutator-plates. The commutator-plates are upon a cylinder, u, and insulated, and this cylinder is to be properly placed and secured by expanding the split end of the shaft by a tapering screw-plug, v.

换向板 t 被展示为在电枢轴的轴承 b 的外部。轴 H 是管状的,并在端部裂开,导线以任何通常的方式穿过轴 H,并连接到各个换向板上。换向板在一个圆柱体 u 上,并被绝缘,利用一个锥形螺旋塞 v 来扩张轴的分裂端,来适合地放置和固定该圆柱体。

I do not claim herein the cores of the field-magnets converging towards the pole-pieces; nor do I claim the method of fastening the base to the lower field-magnet, as this has been claimed in my former application on dynamo-electric machines.

我在此并不主张场磁体的铁芯朝向极靴会聚;我也不主张将基座紧固到较低的场磁体的方法,因为这在我以前关于发电机的申请中已经被主张过。

What I claim is—

我主张的是—

1. In a dynamo-electric machine, the armature constructed of iron disks of various diameters arranged upon the shaft in such a manner that a series of iron bodies is formed, each diminishing in thickness from the center to the periphery, substantially as and for the purposes set forth.

1、在一个发电机中,电枢由不同直径的铁盘构成,铁盘以这样的方式排列在轴上,形成一系列的铁片,每个铁盘的厚度从中心到外围逐渐减小,基本如上所述并用于上述目的。

2. In a dynamo-electric machine, the armature-core having iron disks of various diameters, in combination with inwardly-curved end disks, for the purposes and substantially as set forth.

2、在一个发电机中，电枢铁芯具有不同直径的铁盘，与向内弯曲的端部盘相结合，用于上述目的并基本如上所述。

3. In a dynamo-electric machine, an armature-core having inwardly-curved ends, in combination with the armature-coils, the crossing wires of which coils pass into the concave heads and project equally, substantially as set forth.

3、在一个发电机中，一个电枢铁芯具有向内弯曲的端部，与电枢线圈相结合，电枢线圈的交叉导线相等地进入凹形封头中并相等地突出，基本上如所述。

4. In a dynamo-electric machine, an armature having separate coils superimposed and connected to the commutator-plates in alternating groups, substantially as set forth.

4、在一个发电机中，具有重叠的独立线圈的一个电枢，并且这些线圈以交替线圈组的方式连接到换向板，基本如前所述。

5. An armature for dynamo-electric machines, having a core composed of disks of various diameters, in combination with separate superimposed coils connected to the commutator-plates in alternate groups, substantially as set forth.

5、一种用于发电机的电枢，它具有由不同直径的圆盘组成的铁芯，与按照交替线圈组的方式连接到换向板的独立重叠线圈相结合，基本如上所述。

6. In a dynamo-electric machine, the magnetic frame composed of the cores c c c c, the curved pole-pieces N S, and the connecting-frame with the curved and outwardly-projecting legs e e, substantially as described.

6、一种用于发电机的电枢，磁性框架由铁芯 c c c c、弯曲的极靴 N S 和具有弯曲的且向外突出的支腿 e e 的连接框架所组成，基本如上所述。

Signed by me this 12th day of January, 1886.

由我于 1886 年 1 月 12 日签署。

NIKOLA TESLA.

尼古拉·特斯拉

Witnesses:

GEO. T. PINCKNEY,

WALLACE L. SERRELL.

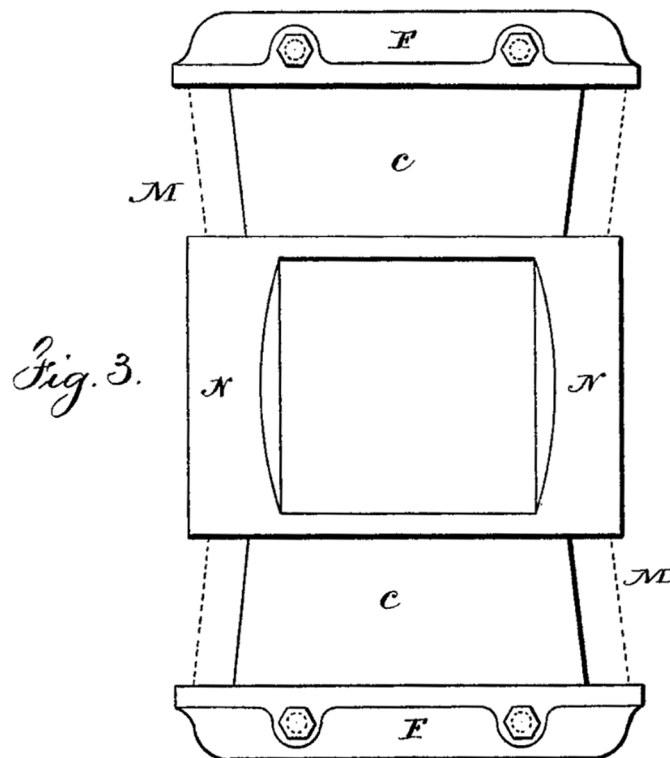
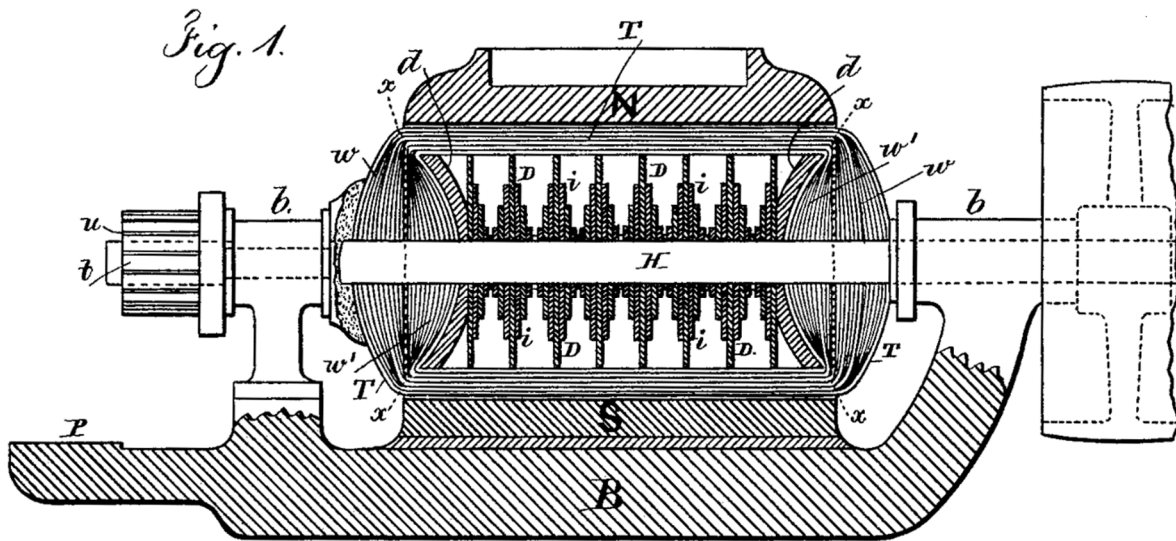
见证人:

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N. TESLA.
DYNAMO ELECTRIC MACHINE.

No. 359,748.

Patented Mar. 22, 1887.



Witnesses

Chas. H. Smith
J. Staley

Inventor

Nikola Tesla
for Lemuel W. Perrell

att.

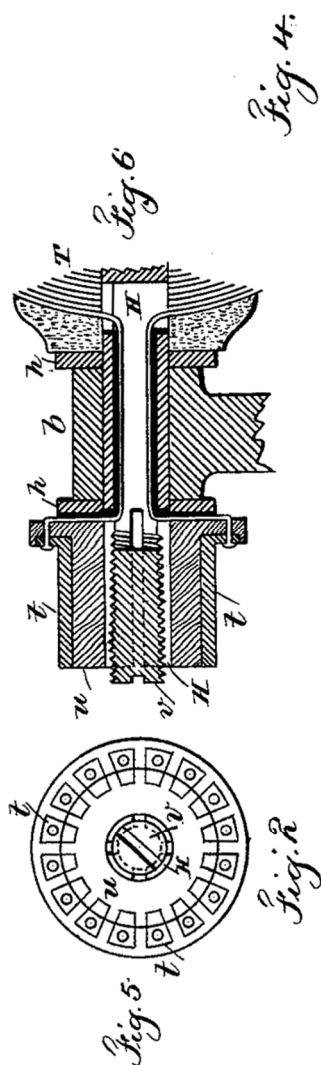
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N. TESLA.
DYNAMO ELECTRIC MACHINE.

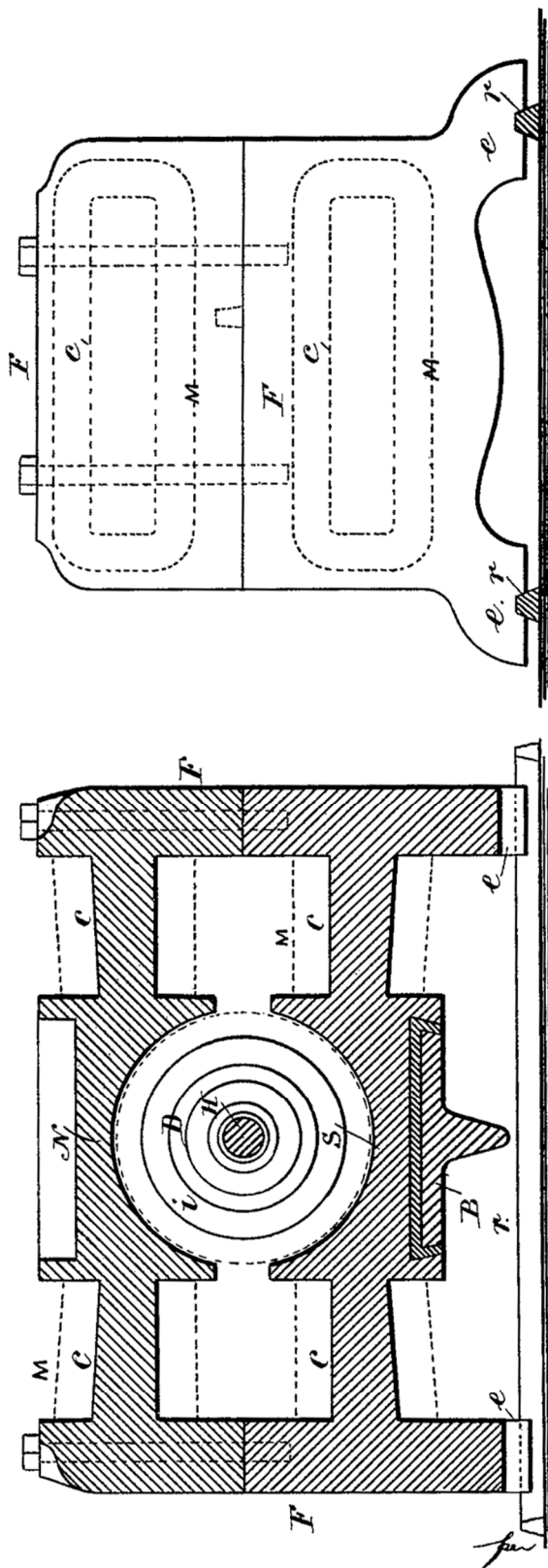
No. 359,748.

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Witnesses

Chas H. Smith
J. Staley



Inventor

Nikola Tesla

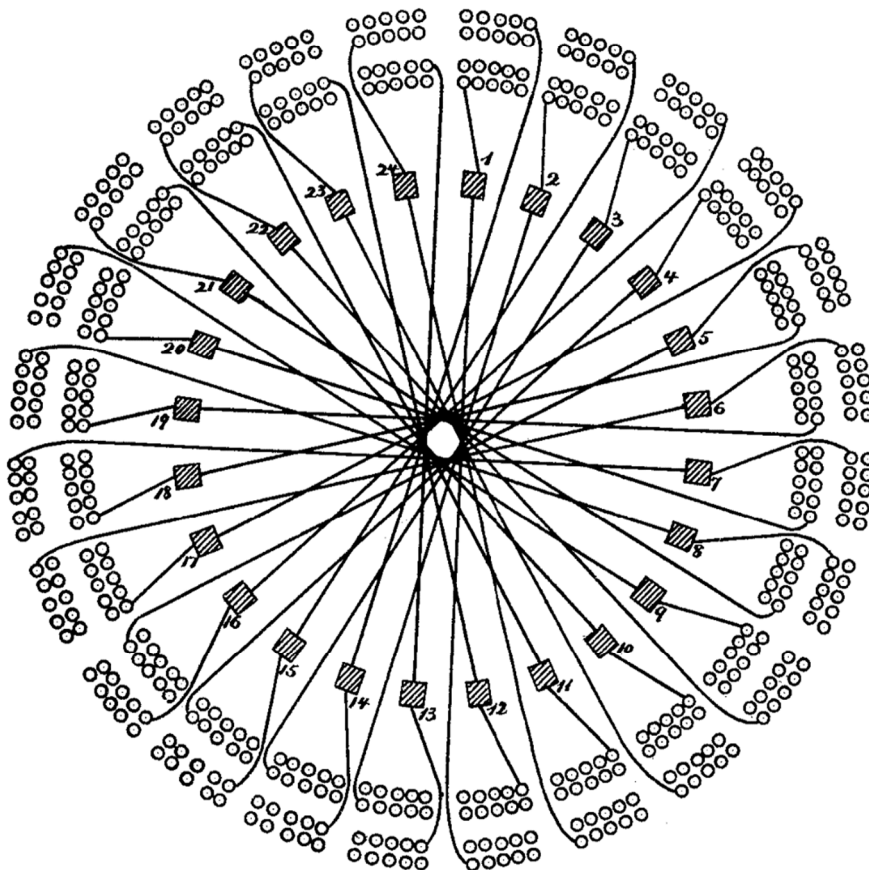
L. W. Ferrell

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Fig. 7.



Witnesses

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ELECTRO-MAGNETIC MOTOR.

电磁电动机

SPECIFICATION forming part of Letters Patent No. 381,968, dated May 1, 1888.

Application filed October 12, 1887. Serial No. 252,132. (No model.)

该说明书形成了颁发于 1888 年 5 月 1 日编号为 381,968 的专利证书的一部分。

申请于 1887 年 10 月 12 日提交。序列号为 252,132。(没有模型)

To all whom it may concern:

致所有相关人士:

Be it known that I, NIKOLA TESLA, from Smiljan Lika, border country of Austria-Hungary, residing at New York, N.Y., have invented certain new and useful Improvements in Electro-Magnetic Motors, of which the following is a specification, reference being had to the drawings accompanying and forming a part of the same.

众所周知，我、尼古拉·特斯拉，来自奥匈帝国边境地区的利卡县的史密里安村，居住在纽约州的纽约市，在电磁电动机方面已经发明了某些新的和有用的改进，以下是该发明一个说明书，必须参考随附的图纸，它已形成了该说明书的一部分。

The practical solution of the problem of the electrical conversion and transmission of mechanical energy involves certain requirements which the apparatus and systems heretofore employed have not been capable of fulfilling. Such a solution, primarily, demands a uniformity of speed in the motor irrespective of its load within its normal working limits. On the other hand, it is necessary, to attain a greater economy of conversion that has heretofore existed, to construct cheaper and more reliable and simple apparatus, and, lastly the apparatus must be capable of easy management, and such that all danger from the use of currents of high tension, which are necessary to an economical transmission, may be avoided.

机械能的电转换和电传输的问题的实际解决方案包括了迄今为止所采用的设备和系统无法满足的某些要求。这种解决方案主要要求电动机的速度要一致，而不管其正常工作限度内的负载如何。另一方面，为了获得迄今为止已经存在的更大的转换的经济性，有必要构造更便宜、更可靠和简单的设备，并且最后，该设备必须能够容易管理，并且使得可以避免来自使用高压电流的所有危险，高压电流对于一种经济的传输是必要的。

My present invention is directed to the production and improvement of apparatus capable of more nearly meeting these requirements than those heretofore available, and though I have described various means for the purpose, they involve the same main principles of construction and mode of operation, which may be described as follows: A motor is employed in which there are two or more independent circuits through which alternate currents are passed at proper intervals, in the manner hereinafter described, for the purpose of effecting a progressive shifting of the magnetism or of the “lines of force” in accordance with the well-known theory, and a consequent action of the motor. It is obvious

that a proper progressive shifting of the lines of force may be utilized to set up a movement or rotation of either element of the motor, the armature, or the field-magnet, and that if the currents directed through the several circuits of the motor are in the proper direction no commutator for the motor will be required; but to avoid all the usual commutating appliances in the system I prefer to connect the motor-circuits directly with those of a suitable alternate-current generator. The practical results of such a system, its economical advantages, and the mode of its construction and operation will be described more in detail by reference to the accompanying diagrams and drawings.

我的发明旨在生产和改进能够比迄今可用的装置更接近满足这些要求的装置,并且尽管我已经描述了用于该目的的各种工具,但是它们涉及相同的主要构造原理和操作模式,可以描述如下:采用了一种电动机,其中有两个或多个独立的电路,不同的交流电以适当的时间间隔,以将在下文中描述方式通过这些电路,目的是根据众所周知的理论实现磁力或“力线”的渐进转移,以及电动机的后续动作。显而易见的是,可以利用磁力线的适当渐进转移来建立电动机、电枢或场磁体的任一组件的运动或旋转,并且如果通过电动机的几个电路的电流方向正确,则不需要电动机的换向器;但为了避免系统中所有常见的换向设备,我更喜欢直接将电动机电路与合适的交流发电机连接。这种系统的实际效果、其经济优势以及其构建和操作的模式将参照附图进行更详细的描述。

Figures 1 to 8 and 1a to 8a, inclusive, are diagrams illustrating the principle of the action of my invention. The remaining figures are views of the apparatus in various forms by means of which the invention may be carried into effect, and which will be described in their order.

图 1 至图 8 和图 1a 至图 8a 是说明我的发明的作用原理的示意图。其余的图是各种形式的装置的视图,通过这些图可以实现本发明,并且将按它们的顺序进行描述。

Referring first to Fig. 9, which is a diagrammatic representation of a motor, a generator, and connecting-circuits in accordance with my invention, M is the motor, and G the generator for driving it. The motor comprises a ring or annulus, R, preferably built up of thin insulated iron rings or annular plates, so as to be as susceptible as possible to variations in its magnetic condition. This ring is surrounded by four coils of insulated wire symmetrically placed, and designated by C C' C' C'. The diametrically-opposite coils are connected up so as to co-operate in pairs in producing free poles on diametrically-opposite parts of the ring. The four free ends thus left are connected to terminals T T' T' T', as indicated. Near the ring, and preferably inside of it, there is mounted on an axis or shaft, a, a magnetic disk, D, generally circular in shape, but having two segments cut away, as shown. This disk is mounted so as to turn freely within the ring R. The generator G is of any ordinary type, that shown in the present instance having field-magnets N S and a cylindrical armature-core, A, wound with the two coils B B'. The free ends of each coil are carried through the shaft a' and connected, respectively, to insulated contact-rings b b' b' b'. Any convenient form of collector or brush bears on each ring and forms a terminal by which the current to and from a ring is conveyed. These terminals are connected to the terminals of the motor by the wires L and L' in the manner indicated, whereby two complete circuits are formed—one including, say, the coils B of the generator and C' C' of the motor, and the other the remaining coils B' and C C of the generator and the motor.

首先参照图 9,它是根据本发明的一个电动机、一个发电机和连接电路的示意图,M 是一个电动机,G 是驱动它的发电机。电动机包括一个环或环形物 R,最好由薄的被绝缘的铁环或

铁质环形板制作，以便尽可能容易地受其磁性条件变化的影响。这个环被对称放置的四个被绝缘的线圈包围，线圈用 $CCC'C'$ 表示。径向相对的线圈连接起来，以便成对地协作，在环的径向相对的部分上产生自由磁极。如此留下的四个游离端连接到终端 $TT'T'T'$ ，如图所示。在环的附近，并且最好在环的内部，在轴 a 上安装有一个磁性盘 D ，该磁性盘 D 通常为圆形，但是有两个部分被切掉了。该盘被安装成在环 R 内自由转动。发电机 G 是任何普通类型的，在本实例中所示的具有场磁体 NS 和被缠绕有两个线圈 $B'B'$ 的一个圆柱形电枢铁芯 A 。每个线圈的自由端穿过轴 a' 并分别连接到被绝缘的接触环 $bbb'b'$ 。任何方便形式的集电器或电刷都倚靠在每个环上，并形成一终端，通过该终端来传送进出环的电流。这些终端通过导线 L 和 L' 以所示的方式连接到电动机的终端，由此形成两个完整的电路——一个包含发电机的线圈 B 和电动机的线圈 $C'C'$ ，另一个包含发电机和电动机的剩余线圈 B' 和 CC 。

It remains now to explain the mode of operation of this system, and for this purpose I refer to the diagrams, Figs. 1 to 8, and 1a to 8a, for an illustration of the various phases through which the coils of the generator pass when in operation, and the corresponding and resultant magnetic changes produced in the motor. The revolution of the armature of the generator between the field-magnets NS obviously produces in the coils $B'B'$ alternating currents, the intensity and direction of which depend upon well-known laws. In the position of the coils indicated in Fig. 1 the current in the coil B is practically nil, whereas the coil B' at the same time is developing its maximum current, and by the means indicated in the description of Fig. 9 the circuit including this coil B' may also include, say, the coils CC of the motor, Fig. 1a. The result, with the proper connections, would be the magnetization of the ring R' , the poles being on the line NS . The same order of connections being observed between the coil B and the coils C' , the latter, when traversed by a current, tend to fix the poles at right angles to the line NS of Fig. 1a. It results, therefore, that when the generator-coils have made one-eighth of a revolution, reaching the position shown in Fig. 2, both pairs of coils C and C' will be traversed by currents and act in opposition, in so far as the location of the poles is concerned. The position of the poles will therefore be the resultant of the magnetizing forces of the coils—that is to say, it will advance along the ring to a position corresponding to one-eighth of the revolution of the armature of the generator. In Fig. 3 the armature of the generator has progressed to one-quarter of a revolution. At the point indicated the current in the coil B is maximum, while in B' it is nil, the latter coil being in its neutral position. The poles of the ring R in Fig. 3a will, in consequence, be shifted to a position ninety degrees from that at the start, as shown. I have in like manner shown the conditions existing at each successive eighth of one revolution in the remaining figures. A short reference to these figures will suffice for an understanding of their significance. Figs. 4 and 4a illustrate the conditions which exist when the generator-armature has completed three-eighths of a revolution. Here both coils are generating current; but the coil B' , having now entered the opposite field, is generating a current in the opposite direction, having the opposite magnetizing effect; hence the resultant pole will be on the line NS , as shown. In Fig. 5 one-half of one revolution of the armature of the generator has been completed, and the resulting magnetic condition of the ring is shown in Fig. 5a. In this phase coil B is in the neutral position while coil B' is generating its maximum current, which is in the same direction as in Fig. 4. The poles will consequently be shifted through one half of the ring. In Fig. 6 the armature has completed five-eighths of a revolution. In this position coil B' develops a less powerful current, but in the same direction as before. The coil B , on the other hand, having entered a field of opposite polarity, generates a current of opposite direction. The resultant poles will therefore be in the line NS , Fig. 6a, or, in other words, the poles of the ring will be shifted along five-eighths of its periphery. Figs. 7 and 7a in the same manner illustrate the phases of the generator and rings at three-quarters of a revolution, and Figs. 8 and 8a the

same at seven-eighths of a revolution of the generator-armature. These figures will be readily understood from the foregoing. When a complete revolution is accomplished, the conditions existing at the start are re-established and the same action is repeated for the next and all subsequent revolutions, and, in general, it will now be seen that every revolution of the armature of the generator produces a corresponding shifting of the poles or lines of force around the ring. This effect I utilize in producing the rotation of a body or armature in a variety of ways—for example, applying the principle above described to the apparatus shown in Fig. 9. The disk D, owing to its tendency to assume that position in which it embraces the greatest possible number of the magnetic lines, is set in rotation, following the motion of the lines or the points of greatest attraction.

现在继续解释该系统的运行模式，为此目的，我参考图 1 至图 8 和图 1a 至图 8a，用于说明在运行时发电机线圈经过的各种相位，以及在电动机中产生的相应的和合成的磁变化。发电机电枢在场磁体 NS 之间的旋转显然会在线圈 BB' 中产生交流电，其强度和方向取决于众所周知的定律。在图 1 所示的线圈位置，线圈 B 中的电流实际上为零，而线圈 B' 同时正在发展出它的最大电流，并且通过图 9 的描述中所示的工具，包含线圈 B' 的电路也可以包含，比如说，图 1a 的电动机的线圈 C C'。通过适当的连接，结果将是环 R' 的磁化，磁极在线 NS 上。会在线圈 B 和线圈 C' 之间观察到相同的连接顺序，当电流通过线圈 C' 时，线圈 C' 倾向于将磁极固定成与图 1a 的线 NS 成直角。因此，当发电机线圈已经旋转了八分之一转，到达图 2 所示的位置时，两对线圈 C 和 C' 将被电流穿过，并且就磁极的位置而言，作用相反。因此，磁极的位置将是线圈的磁力的合力，也就是说，它将沿着环前进到对应于发电机电枢的八分之一转的位置。在图 3 中，发电机的电枢已经前进到四分之一转。在所示的点上，线圈 B 中的电流最大，而在 B' 中，电流为零，后一个线圈处于中性位置。因此，如图所示，图 3a 中的环 R 的磁极将从开始位置转移 90 度。我以同样的方式在其余图中展示了每个逐次的八分之一转的情况。对这些数字的简短参考将足以理解它们的重要性。图 4 和图 4a 展示了当发电机电枢完成八分之三转时的情况。这里两个线圈都在产生电流；但是现在已经进入磁场相反的线圈 B' 产生方向相反的电流，具有相反的磁化效果；因此，合成极点将在线 NS 上，如图所示。在图 5 中，发电机的电枢已经完成了一转的一半，并且在图 5a 中展示了环的合成磁性状态。在这一相位，线圈 B 处于中性位置，而线圈 B' 正在产生它的最大电流，其方向与图 4 中的方向相同。磁极将因此转移通过环的一半。在图 6 中，电枢已经完成了一转的八分之五。在这个位置，线圈 B' 产生一个较小的电流，但方向与前面相同。另一方面，线圈 B 已经进入一个极性相反的磁场，产生一个方向相反的电流。因此，合成磁极将在图 6a 的线 NS 上，或者换句话说，环的磁极将沿其周长的八分之五进行转移。图 7 和图 7a 以同样的方式展示了发电机和环在四分之三转时的相位，图 8 和图 8a 展示了发电机电枢在八分之七转时的相位。根据前述内容，这些图将很容易理解。当完成一个完整的旋转时，在开始时存在的情况被重新建立，并且相同的动作被重复用于下一次和所有随后的旋转，并且，通常，现在将会看到，发电机电枢的每一次旋转都会产生围绕环的磁极或磁力线的一次相应转移。我利用这种效应以多种方式产生物体或电枢的旋转——例如，将上述原理应用于图 9 所示的装置。盘 D，由于它倾向于采用能包围最大可能数量的磁力线的位置，所以被设置成随着磁力线或最大吸引点的运动而旋转。

The disk D in Fig. 9 is shown as cut away on opposite sides; but this, I have found, is not essential to effecting its rotation, as a circular disk, as indicated by dotted lines, is also set in rotation. This phenomenon I attribute to a certain inertia or resistance inherent in the metal to the rapid shifting of the lines of force through the same, which results in a continuous tangential pull upon the disk, causing its rotation. This seems to be confirmed by the fact that a circular disk of steel is more effectively rotated

than one of soft iron, for the reason that the former is assumed to possess a greater resistance to the shifting of the magnetic lines.

图 9 中的盘 D 被显示为在相对的两侧被切掉；但我发现，这并不是影响其旋转的关键，因为虚线所示的一个盘也在旋转。这种现象我归因于某种惯性和在金属中对穿过金属的力线的快速转移有着固有的阻力，这导致持续施加在盘上的切向拉力，引起了盘的旋转。这似乎被一个事实所证实，这个事实就是圆形钢盘比软铁盘能更有效地旋转，因为前者被认为对磁力线的转移有着更大的阻力。

In illustration of other forms of my invention, I shall now describe the remaining figures of the drawings.

为了说明我的发明的其他形式，我现在将描述附图的其余部分。

Fig. 10 is a view in elevation and part vertical section of a motor. Fig. 12 is a top view of the same with the field in section and a diagram of connections. Fig. 11 is an end or side view of a generator with the fields in section. This form of motor may be used in place of that shown above. D is a cylindrical or drum-armature core, which, for obvious reasons, should be split up as far as practicable to prevent the circulation within it of currents of induction. The core is wound longitudinally with two coils, E and E', the ends of which are respectively connected to insulated contact-rings d d' d' d', carried by the shaft a, upon which the armature is mounted. The armature is set to revolve within an iron shell, R', which constitutes the field-magnet, or other element of the motor. This shell is preferably formed with a slot or opening, r, but it may be continuous, as shown by the dotted lines, and in this event it is preferably made of steel. It is also desirable that this shell should be divided up similarly to the armature and for similar reasons. As a generator for driving this motor I may use the device shown in Fig. 11. This represents an annular or ring-armature, A, surrounded by four coils, F F' F' F', of which those diametrically opposite are connected in series, so that four free ends are left, which are connected to the insulated contact-rings b b' b' b'. The ring is suitably mounted on a shaft, a', between the poles N S. The contact-rings of each pair of generator-coils are connected to these of the motor, respectively, by means of contact-brushes and the two pairs of conductors L L and L' L', as indicated diagrammatically in Fig. 12. Now it is obvious from consideration of the preceding figures that the rotation of the generator-ring produces currents in the coils F F', which, being transmitted to the motor-coils, impart to the core of the latter magnetic poles constantly shifting or whirling around the core. This effect sets up a rotation of the armature owing to the attractive force between the shell and the poles of the armature, but inasmuch as the coils in this case move relative to the shell or field-magnet the movement of the coils is in the opposite direction to the progressive shifting of the poles.

图 10 是电动机的正视图和部分垂直截面图。图 12 是该装置的顶视图，具有截面图和连接示意图。图 11 是发电机的端视图或侧视图，其场磁体处于截面中。这种形式的电动机可以用来代替上面所示的电动机。D 是一个圆柱形或鼓形电枢铁芯，由于明显的原因，应尽可能将其分割开，以防止感应电流在其中循环。铁芯上纵向缠绕有两个线圈 E 和 E'，线圈的端部分别连接到由轴 a 携带的绝缘接触环 d d' d' d' 上，电枢安装在轴 a 上。电枢被设置成在铁壳 R' 内旋转，铁壳 R' 构成了场磁体或电动机的其它组件。该壳体最好形成一个沟槽或开口 r，但是该壳体可以是连续的，如虚线所示，并且在这种情况下，它首选由钢制成。同样可取的是，这种壳体应该以类似于电枢的方式并且出于类似的原因而被分割。作为驱动该电动机的发电机，我可以使用的图 11 所示的装置。这表示由四个线圈 F F' F' F' 包围的环或环状电枢 A，

其中径向相对的线圈串联连接，从而留下四个游离端，这四个游离端连接到被绝缘的接触环 $b b b' b'$ 上。该环适当地安装在轴 a' 上，该轴位于磁极 NS 之间。每对发电机线圈的接触环分别通过接触电刷和两对导体 $L L$ 和 $L' L'$ 连接到电动机的接触环上，如图 12 所示。现在，从前面的图中可以明显看出，发电机环的旋转在线圈 FF' 中产生电流，该电流被传送到电动机线圈，使电动机线圈的磁极在铁芯周围不断转移或旋转。由于壳体和电枢的磁极之间的吸引力，这种效果建立了电枢的旋转，但是因为在这种情况下线圈相对于壳体或场磁体移动，所以线圈的移动方向与磁极的逐渐移动的方向相反。

Other arrangements of the coils of both generator and motor are possible, and a greater number of circuits may be used, as will be seen in the two succeeding figures.

发电机和电动机的线圈的其他布置也是可以的，并且可以使用更多数量的电路，如将在随后的两幅图中看到的。

Fig. 13 is a diagrammatic illustration of a motor and a generator constructed and connected in accordance with my invention. Fig. 14 is an end view of the generator with its field-magnets in section. The field of the motor M is produced by six magnetic poles, $G' G'$, secured to or projecting from a ring or frame, H . These magnets or poles are wound with insulated coils, those diametrically opposite to each other being connected in pairs so as to produce opposite poles in each pair. This leaves six free ends, which are connected to the terminals $T' T' T' T' T' T'$. The armature, which is mounted to rotate between the poles, is a cylinder or disk, D , of wrought-iron, mounted on the shaft a . Two segments of the same are cut away, as shown. The generator for this motor has in this instance an armature, A , wound with three coils, $K K' K''$, at sixty degrees apart. The ends of these coils are connected, respectively, to insulated contact-rings $e e' e' e' e'' e''$. These rings are connected to those of the motor in proper order by means of collecting-brushes and six wires, forming three independent circuits. The variations in the strength and direction of the currents transmitted through these circuits and traversing the coils of the motor produce a steadily-progressive shifting of the resultant attractive force exerted by the poles G' upon the armature D , and consequently keep the armature rapidly rotating. The peculiar advantage of this disposition is in obtaining a more concentrated and powerful field. The application of this principle to systems involving multiple circuits generally will be understood from this apparatus.

图 13 是根据我的发明进行构造和连接的电动机和发电机的示意图。图 14 是发电机的端视图，其场磁体处于截面中。电动机 M 的磁场由六个磁极 $G' G'$ 产生，这些磁极被固定在环或框架 H 上或从环或框架 H 上突出。这些磁体或磁极上缠绕有被绝缘的线圈，彼此径向相对的线圈成对连接，以便在每对线圈中产生相反的磁极。这留下了六个游离端，它们连接到终端 $T' T' T' T' T' T'$ 。安装在磁极之间旋转的电枢是一块锻铁制成的圆柱或盘 D ，安装在轴 a 上。如图所示，相同的两个分段被切掉。在这种情况下，用于这种电动机的发电机有一个电枢 A ，它绕有三个相距 60 度的线圈 $K K' K''$ 。这些线圈的末端分别连接到被绝缘的接触环 $e e' e' e' e'' e''$ 。这些环通过集电刷和六根导线以适当的顺序连接到电动机的环上，形成三个独立的电路。通过这些电路来传输流经电动机线圈的电流，这些电流的强度和方向的变化产生了由磁极 G' 施加在电枢 D 上的合成吸引力的稳定渐进的转移，并因此维持电枢快速旋转。这种配置的特殊优势是获得一个更集中和更强大的磁场。从该装置通常可以理解该原理在包含了多个电路的系统中的应用。

Referring, now, to Figs. 15 and 16, Fig. 15 is a diagrammatic representation of a modified disposition

of my invention. Fig. 16 is a horizontal cross-section of the motor. In this case a disk, D, of magnetic metal, preferably cut away at opposite edges, as shown in dotted lines in Fig. 15, is mounted so as to turn freely inside two stationary coils, N' N'', placed at right angles to one another. The coils are preferably wound on a frame, O, of insulating material, and their ends are connected to the fixed terminals T T' T' T'. The generator G is a representative of that class of alternating-current machines in which a stationary induced element is employed. That shown consists of revolving permanent or electro-magnet, A, and four independent stationary magnets, P P', wound with coils those diametrically opposite to each other being connected in series and having their ends secured to the terminals t t' t' t'. From these terminals the currents are led to the terminals of the motor, as shown in the drawings. The mode of operation is substantially the same as in the previous cases, the currents traversing the coils of the motor having the effect to turn the disk D. This mode of carrying out the invention has the advantage of dispensing with the sliding contacts in the system.

现在参照图 15 和图 16, 图 15 是本发明的一种改进配置的示意图。图 16 是电动机的水平截面图。在这种情况下, 金属磁性盘 D 的对边沿着图 15 中的虚线被切掉, 然后安装在两个静态线圈 N'N'' 内以便能自由转动。线圈首先缠绕在用绝缘材料制成的框架 O 上, 并且它们的端部连接到被固定的终端 T T' T' T' 上。发电机 G 是采用静态感应组件的那类交流电机的一个代表。如图所示, 该发电机由旋转的永磁体或电磁体 A 和四个独立的静态磁体 P P' 组成, 这些磁体上缠绕有彼此径向相对的线圈, 这些径向相对的线圈串联连接并且它们的端部被固定在终端 t t' t' t' 上。如图所示, 电流从这些终端被引导至电动机的终端。操作模式基本上与前面的情况相同, 流经电动机线圈的电流具有转动盘 D 的效果。实施本发明的这种模式具有在系统中省去滑动触点的优点。

In the forms of motor above described only one of the elements, the armature or the field-magnet, is provided with energizing-coils. It remains, then, to show how both elements may be wound with coils. Reference is therefore had to Figs. 17, 18, and 19. Fig. 17 is an end view of such a motor. Fig. 18 is a similar view of the generator with the field-magnets in section, and Fig. 19 is a diagram of the circuit-connections. In Fig. 17 the field-magnet of the motor consists of a ring, R, preferably of thin insulated iron sheets or bands with eight pole pieces, G', and corresponding recesses, in which four pairs of coils, V, are wound. The diametrically opposite pairs of coils are connected in series and the free ends connected to four terminals, w, the rule to be followed in connecting being the same as hereinbefore explained. An armature, D, with two coils, E E', at right angles to each other, is mounted to rotate inside of the field-magnet R. The ends of the armature-coils are connected to two pairs of contact-rings, d d' d' d', Fig. 19. The generator for this motor may be of any suitable kind to produce currents of the desired character. In the present instance it consists of a field-magnet, N S, and an armature, A, with two coils at right angles, the ends of which are connected to four contact-rings, b b' b' b', carried by its shaft. The circuit-connections are established between the rings on the generator-shaft and those on the motor-shaft by collecting brushes and wires, as previously explained. In order to properly energize the field-magnet of the motor, however, the connections are so made with the armature coils or wires leading thereto that while the points of greatest attraction or greatest density of magnetic lines of force upon the armature are shifted in one direction those upon the field-magnet are made to progress in an opposite direction. In other respects the operation is identically the same as in the other cases cited. This arrangement results in an increased speed of rotation. In Figs. 17 and 19, for example, the terminals of each set of field-coils are connected with the wires to the two armature-coils in such a way that the field-coils will maintain opposite poles in advance of the poles of the armature.

在上述电动机形式中，只有一个组件，即电枢或场磁体，配有励磁线圈。接下来，我们将展示如何用线圈来缠绕这两个组件。因此必须参考图 17、图 18 和图 19。图 17 是这种电动机的端视图。图 18 是带有场磁体的发电机的类似截面图，图 19 是电路连接图。在图 17 中，电动机的场磁体由一个环 R 组成，该环最好由薄的被绝缘的铁片或铁带构成，该铁片或铁带具有八个极片 G'和相应的沟槽，在沟槽中缠绕有四对线圈 V。径向相对的线圈相互组对并串联连接，它们的游离端连接到四个端子 w 上，连接中遵循的规则与上文解释的相同。带有两个相互成直角的线圈 E E'的电枢 D 被安装在场磁体 R 的内部用来旋转。电枢线圈的末端连接到两对接触环 d d' d' d'，如图 19 所示。用于该电动机的发电机可以是任何合适的类型，来产生所需特性的电流。在目前的情况下，它包括一个场磁体 NS 和一个电枢 A，电枢 A 的两个线圈成直角排列，其末端连接到四个接触环 b b' b' b'，由轴携带。如前所解释的，通过集电电刷和集电导线，在发电机轴上的环和电动机轴上的环之间建立电路连接。然而，为了适当地励磁电动机的场磁铁，电枢线圈或导线的连接是这样的，即施加在电枢上最强吸引的点或磁力线密度最大点沿着一个方向转移，而场磁体上的那些点是沿着相反的方向移动。在其他方面，运行与引用过的其他情况完全相同。这种布置导致旋转速度增加。例如，在图 17 和图 19 中，每组励磁线圈的终端用导线连接到两个电枢线圈上，以这样的方式励磁线圈将先于电枢的磁极维持相反的磁极。

In the drawings the field-coils are in shunts to the armature, but they may be in series or in independent circuits.

在图中，励磁线圈与电枢并联，但它们可以串联连接或在各自独立的电路中。

It is obvious that the same principle may be applied to the various typical forms of motor hereinbefore described.

显然，相同的原理可以应用于上文描述的各种典型形式的电动机。

Having now described the nature of my invention and some of the various ways in which it is or may be carried into effect, I would call attention to certain characteristics which the applications of the invention possess and the advantages which the invention secures.

现在已经描述了我的发明的性质和一些实现或可能实现它的各种方式，我想提请注意本发明的应用所具有的某些特征和本发明所确保的优势。

In my motor, considering for convenience that represented in Fig. 9, it will be observed that since the disk D has a tendency to follow continuously the points of greatest attraction, and since these points are shifted around the ring once for each revolution of the armature of the generator, it follows that the movement of the disk D will be synchronous with that of the armature A. This feature by practical demonstrations I have found to exist in all other forms in which one revolution of the armature of the generator produces a shifting of the poles of the motor through three hundred and sixty degrees.

在我的电动机中，为了方便起见，考虑图 9 所示的情况，可以观察到，由于盘 D 具有持续跟随最大吸引点的趋势，并且由于发电机电枢每转一圈，这些点围绕环转移一次，因此盘 D 的运动将与电枢 A 的运动同步。我通过实践证明这一特点存在于所有其他形式中，其中发电机电枢的一次旋转产生电动机磁极的三百六十度的转移。

In the particular construction shown in Fig. 15, or in others constructed on a similar plan, the number of alternating impulses resulting from one revolution of the generator armature is double as compared with the preceding cases, and the polarities in the motor are shifted around twice by one revolution of the generator-armature. The speed of the motor will, therefore, be twice that of the generator. The same result is evidently obtained by such a disposition as that shown in Fig. 17, where the poles of both elements are shifted in opposite directions.

在图 15 所示的特殊结构中，或在以类似方案构建的其他结构中，发电机电枢的一次旋转产生的交变脉冲的数量是前面情况的两倍，发电机电枢的一次旋转使得电动机的极性转移两次。因此，电动机的速度将是发电机速度的两倍。通过如图 17 所示的这种布置，显然可以获得相同的结果，其中两个组件的磁极沿着相反的方向转移。

Again, considering the apparatus illustrated by Fig. 9 as typical of the invention, it is obvious that since the attractive effect upon the disk D is greatest when the disk is in its proper relative position to the poles developed in the ring R—that is to say, when its ends or poles immediately follow those of the ring—the speed of the motor for all the loads within the normal working limits of the motor will be practically constant. It is clearly apparent that the speed can never exceed the arbitrary limit as determined by the generator, and also that within certain limits at least the speed of the motor will be independent of the strength of the current.

再一次，将图 9 所示的装置视为本发明的典型，很明显，由于当盘 D 处于相对于环 R 中形成的磁极的适当位置时，对盘 D 的吸引作用最大，也就是说，当其端部或磁极紧紧跟随环的磁极时，对于电动机正常工作限度内的所有负载，电动机的速度实际上是恒定的。很明显，速度永远不会超过由发电机确定的任意极限，并且至少在某些限度内，电动机的速度将与电流的强度无关。

It will now be more readily seen from the above description how far the requirements of a practical system of electrical transmission of power are realized in my invention. I secure, first, a uniform speed under all loads within the normal working limits of the motor without the use of any auxiliary-regulator; second, synchronism between the motor and generator; third, greater efficiency by more direct application of the current, no commutating devices being required on either the motor or generator; fourth, cheapness and simplicity of mechanical construction and economy in maintenance; fifth, the capability of being very easily managed or controlled; and, sixth, diminution of danger from injury to persons and apparatus.

现在从以上描述中可以更容易地看出，在我的发明中，电力传输的一个实用的系统的要求在多大程度上得以实现了。首先，在不使用任何辅助调节器的情况下，在电动机的正常工作限度内，确保所有负载下的一致速度；第二，电动机和发电机之间的同步性；第三，通过更直接地应用电流而获得更高的效率，在电动机或发电机上都不需要换向装置；第四，机械结构的廉价和简单以及维护的经济性；第五，非常容易管理或控制；第六，减少对人员和设备伤害的危险。

These motors may be run in series, multiple arc or multiple series, under conditions well understood by those skilled in the art.

在本领域技术人员熟知的条件下，这些电动机可以串联连接、并联或串并联的方式运行。

The means or devices for carrying out the principle may be varied to a far greater extent than I have been able to indicate; but I regard as within my invention, and I desire to secure by Letters Patent in general, motors containing two or more independent circuits through which the operating-currents are led in the manner described. By “independent” I do not mean to imply that the circuits are necessarily isolated from one another, for in some instances there might be electrical connections between them to regulate or modify the action of the motor without necessarily producing a new or different action.

执行该原理的工具或设备可以变化到一个远超过我已经能表明的范围；但我把它们看作是在我的发明范围内，并且我希望通过普通的专利证书来确保包含两个或多个独立电路的电动机，工作电流以所述方式通过这些独立电路。“独立”并不意味着电路必须彼此隔离，因为在某些情况下，它们之间可以用电连接来调节或修改电动机的动作，而不一定产生新的或不同的动作。

I am aware that the rotation of the armature of a motor wound with two energizing-coils at right angles to each other has been effected by an intermittent shifting of the energizing effect of both coils through which a direct current by means of mechanical devices has been transmitted in alternately-opposite directions; but this method or plan I regard as absolutely impracticable for the purpose for which my invention is designed—at least on any extended scale—for the reasons, mainly, that a great waste of energy is necessarily involved unless the number of energizing-circuits is very great, and that the interruption and reversal of a current of any considerable strength by means of any known mechanical devices is a matter of the greatest difficulty and expense.

我知道缠绕了两个相互成直角的励磁线圈的一个电动机的电枢的旋转受到两个线圈的励磁效果的间歇转移的影响，利用机械装置流经这两个线圈的直流电在交替相反的方向上传输；但是我认为这种方法或方案对于我的发明的目的来说是绝对不可行的——至少在任何扩展的范围内——主要的原因是，必然涉及到很大的能量浪费，除非励磁电路的数量非常大，并且通过任何已知的机械装置来中断和逆转任何相当大强度的电流是最困难和最费钱的事情。

In this application I do not claim the method of operating motors which is herein involved, having made separate application for such method.

在本申请中，我没有主张这里所涉及的运行电动机的方法，而是对这种方法提出了单独的申請。

I therefore claim the following:

因此，我主张如下：

1. The combination, with a motor containing separate or independent circuits on the armature or field-magnet, or both, of an alternating-current generator containing induced circuits connected independently to corresponding circuits in the motor, whereby a rotation of the generator produces a progressive shifting of the poles of the motors, as herein described.

1、一个交流发电机与一个电动机的组合，该电动机在电枢或场磁体或两者上包含有分开或独立的电路，该交流发电机包含独立连接到电动机中相应电路的感应电路，由此发电机的旋转产生电动机磁极的渐进转移，如本文所述。

2. In a system for the electrical transmission of power, the combination of a motor provided with two or more independent magnetizing-coils and an alternating-current generator containing induced coils corresponding to the motor-coils, and circuits connecting directly the motor and generator coils in such order that the currents developed by the generator will be passed through the corresponding motor-coils, and thereby produce a progressive shifting of the poles of the motor, as herein set forth.

2、在一个电力传输系统中，存在一个组合，它包括配备有两个或多个独立磁化线圈的电动机；对应于电动机线圈的感应线圈的交流发电机；以及直接连接电动机和发电机线圈的电路，使得由发电机产生的电流将通过对应的电动机线圈，从而产生电动机磁极的渐进转移，如本文所述。

3. The combination, with a motor having an annular or ring-shaped field-magnet and a cylindrical or equivalent armature, and independent coils on the field-magnet or armature, or both, of an alternating-current generator having correspondingly independent coils, and circuits including the generator-coils and corresponding motor-coils in such manner that the rotation of the generator causes a progressive shifting of the poles of the motor in the manner set forth.

3. 存在一个组合，它包括具有一个环形场磁铁和一个圆柱形或等效的电枢的电动机；以及在场磁铁或电枢上或在两者上的独立线圈；具有相应的独立线圈的一个交流发电机；以及包含发电机线圈和相应电动机线圈的电路，使得发电机的旋转以所述方式引起电动机磁极的渐进转移。

4. In a system for the electrical transmission of power, the combination of the following instrumentalities, to wit: a motor composed of a disk or its equivalent mounted within a ring or annular field-magnet, which is provided with magnetizing-coils connected in diametrically-opposite pairs or groups to independent terminals, a generator having induced coils or groups of coils equal in number to the pairs or groups of motor-coils, and circuits connecting the terminals of said coils to the terminals of the motor, respectively, and in such order that the rotation of the generator and the consequent production of alternating currents in the respective circuits produces a progressive shifting of the poles of the motor, as hereinbefore described.

4、在用于电力传输的一个系统中，以下装置的组合，即：由安装在环形或环状场磁体内的盘或其等效物组成的电动机，它配备有磁化线圈，这些磁化线圈以径向相对的对或组连接到独立终端上；具有数量等于电动机线圈对或组的感应线圈或线圈组的一个发电机；以及将所述线圈的终端分别连接到电动机终端的电路，并且以这样的顺序，使得发电机的旋转和由此在各自电路中产生的交流电导致了电动机磁极的渐进转移，如上文所述。

NIKOLA TESLA.

尼古拉·特斯拉

Witnesses:

FRANK E. HARTLEY,

FRANK B. MURPHY.

见证人:

弗兰克·哈特利、弗兰克·B·墨菲。

(No Model.)

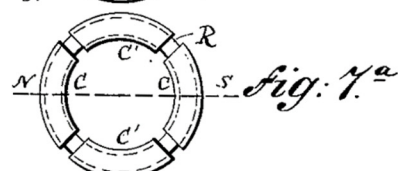
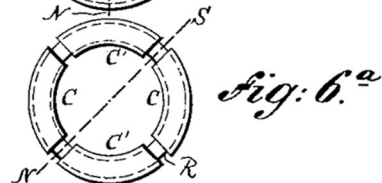
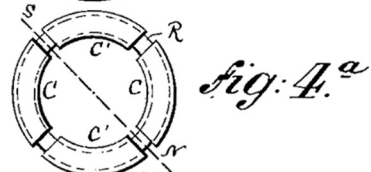
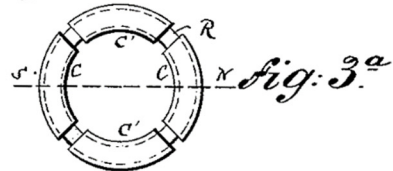
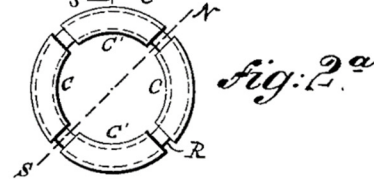
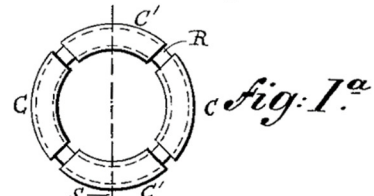
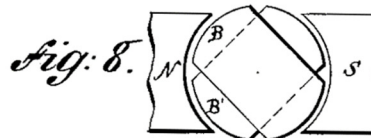
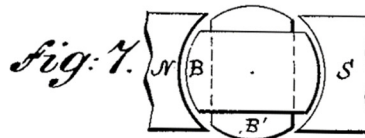
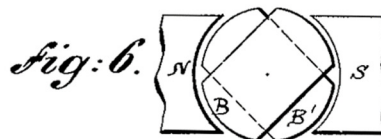
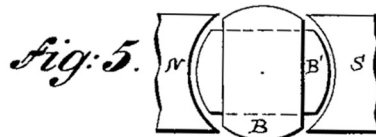
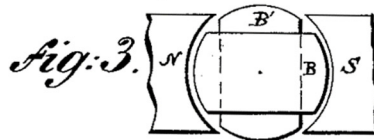
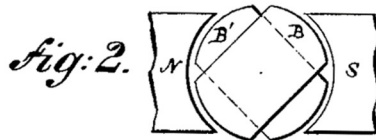
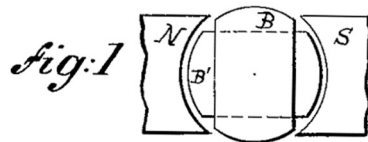
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N. TESLA.

ELECTRO MAGNETIC MOTOR.

No. 381,968.

Patented May 1, 1888.



WITNESSES:

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INVENTOR.

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(No Model.)

4 Sheets—Sheet 2.

N. TESLA.

ELECTRO MAGNETIC MOTOR.

No. 381,968.

Patented May 1, 1888.

Fig. 9.

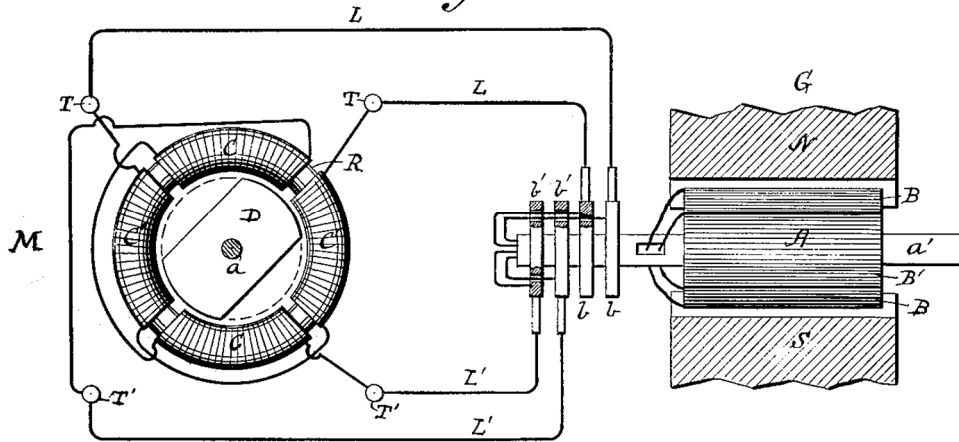


Fig. 10.

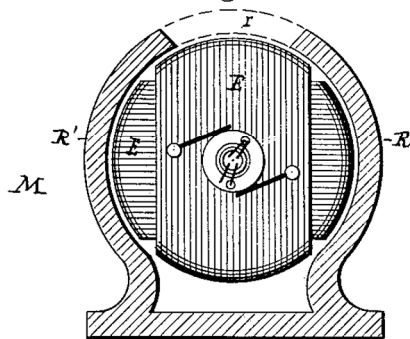


Fig. 11.

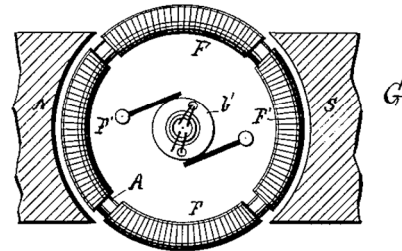
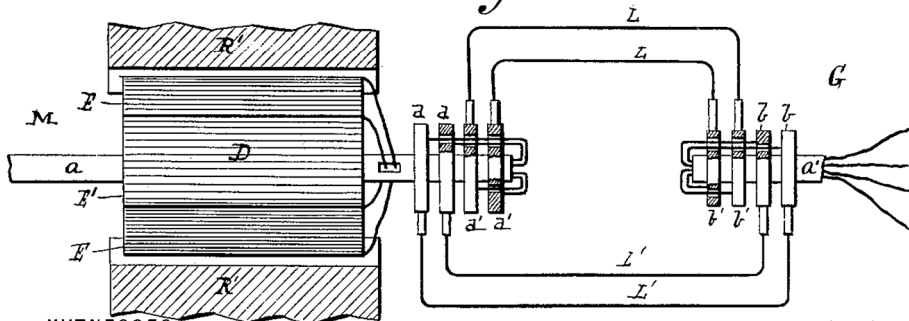


Fig. 12.



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(No Model.)

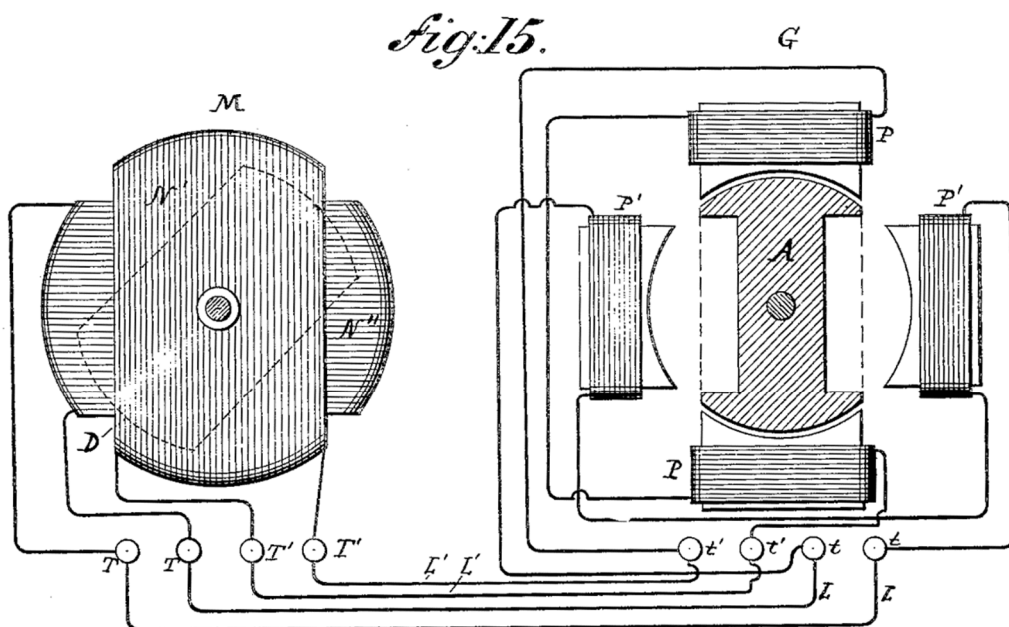
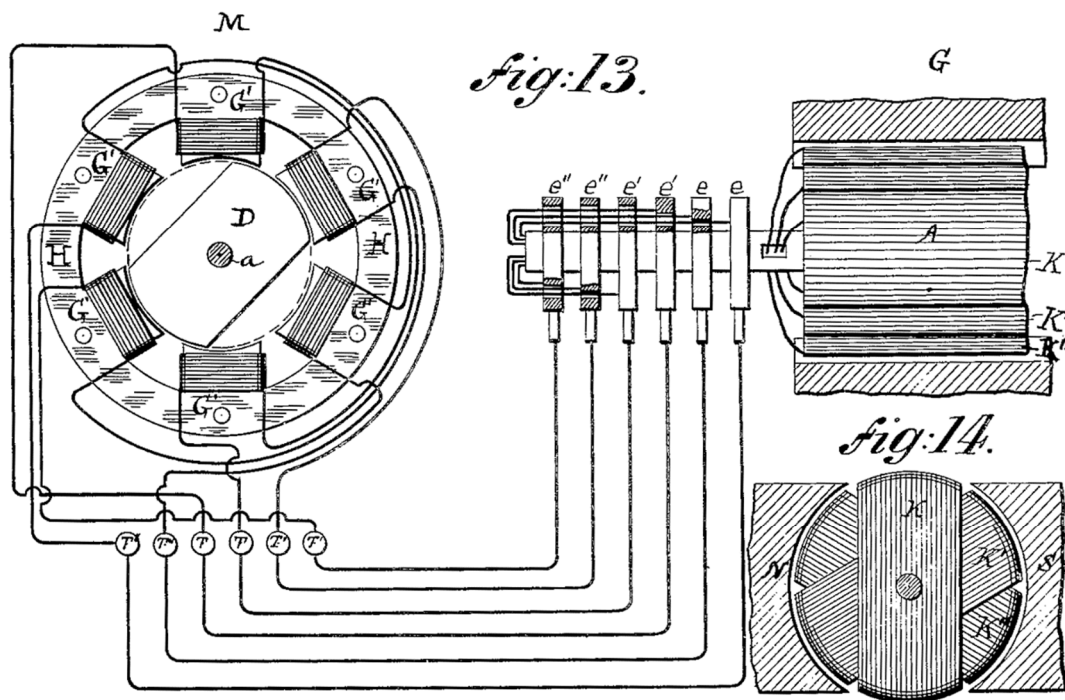
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N. TESLA.

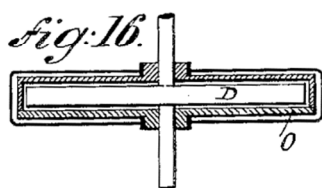
ELECTRO MAGNETIC MOTOR.

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(No Model.)

4 Sheets—Sheet 4.

N. TESLA.

ELECTRO MAGNETIC MOTOR.

No. 381,968.

Patented May 1, 1888.

Fig: 17.

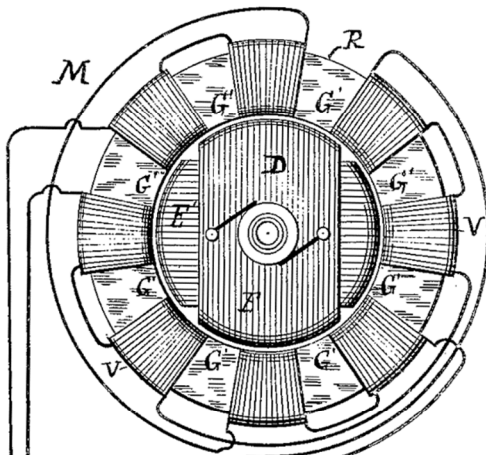


Fig: 18.

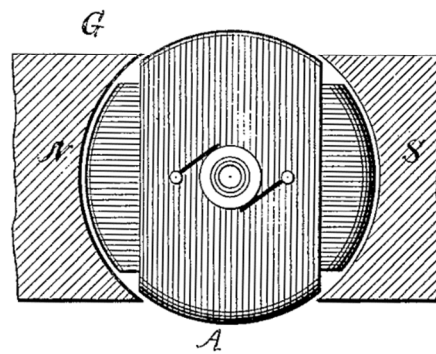
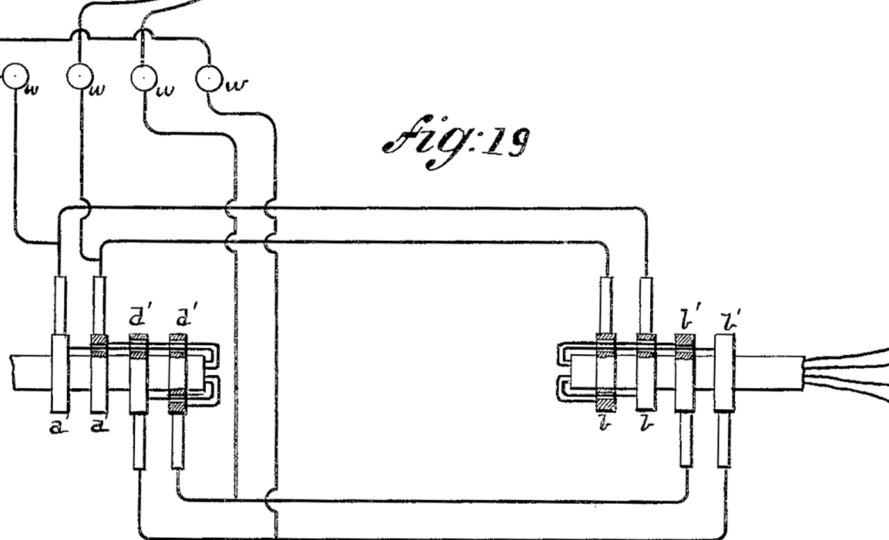


Fig: 19



WITNESSES:

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ELECTRO-MAGNETIC MOTOR.

电磁电动机

SPECIFICATION forming part of Letters Patent No. 381,969, dated May 1, 1888.

Application filed November 30, 1887. Serial No. 256,562. (No model.)

该说明书形成了颁发于 1888 年 5 月 1 日编号为 381,969 的专利证书的一部分。

申请于 1887 年 11 月 30 日提交。序列号为 256,562。(没有模型)

To all whom it may concern:

致所有相关人士：

Be it known that I, NIKOLA TESLA, from Smiljan Lika, border country of Austria-Hungary, now residing in New York, in the county and State of New York, have invented certain new and useful Improvements in Electro-Magnetic Motors, of which the following is a specification, reference being had to the drawings accompanying and forming a part of the same.

众所周知，我、尼古拉·特斯拉，来自奥匈帝国边境地区的利卡县的史密里安村，居住在纽约州纽约郡纽约市，在电磁电动机方面已经发明了某些新的和有用的改进，以下是该发明的说明书，必须参考随附的图纸，它已形成了该说明书的一部分。

In an application filed by me October 12, 1887, No. 252,132, I have shown and described a novel form of electro-magnetic motor and a mode of operating the same, which may be generally described as follows: The motor is wound with coils forming independent energizing-circuits on either the armature or field-magnet, or both, (it is sufficient for present purposes to consider the case in which the coils are on the armature alone,) and these coils are connected up with corresponding circuits on an alternating-current generator. As the result of this, currents of alternately-opposite direction are sent through the energizing-coils of the motor in such manner as to produce a progressive shifting or rotation of the magnetic poles of the armature. This movement of the poles of the armature obviously tends to rotate the armature in the opposite direction to that in which the movement of the poles takes place, owing to the attractive force between said poles and the field-magnets, and the speed of rotation increases from the start until it equals that of the generator, supposing both motor and generator to be alike.

在我于 1887 年 10 月 12 日提交的第 252,132 号申请中，我已经展示并描述了一种新颖形式的电磁电动机及其操作模式，它可大致描述如下：该电动机在电枢或场磁体上或两者上缠绕有形成独立励磁电路的线圈，(为了本发明的目的，考虑线圈仅在电枢上的情况就足够了)，并且这些线圈与交流发电机上的相应电路连接。因此，交替相反方向的电流通过电动机的励磁线圈，从而产生电枢磁极的渐进转移或旋转。由于所述磁极和场磁体之间的吸引力，电枢磁极的这种运动显然倾向于使电枢在与磁极运动发生的方向相反的方向上旋转，并且假设电动机和发电机是相同的，旋转速度从开始增加直到它等于发电机的速度。

As the poles of the armature are shifted in a direction opposite to that in which the armature rotates, it

will be apparent that when the normal speed is attained the poles of the armature will assume a fixed position relative to the field-magnet, and that in consequence the field-magnets will be energized by magnetic induction, exhibiting two distinct poles, one in each of the pole-pieces. In starting the motor, however, the speed of the armature being comparatively slow, the pole-pieces are subjected to rapid reversals of magnetic polarity; but as the speed increases these reversals become less and less frequent, and finally cease when the movement of the armature become synchronous with that of the generator. This being the case, the field-cores and pole-pieces of the motor become a magnet, but by induction only.

当电枢的磁极在与电枢旋转方向相反的方向上转移时，很明显，当达到正常速度时，电枢的磁极将相对于场磁体呈现出固定位置，因此场磁体将通过磁感应被励磁，呈现两个不同的磁极，每个极靴中有一个。然而，在启动电动机时，电枢的速度相对较慢，极靴会经历磁极的快速反转；但是随着速度的增加，这种反转变变得越来越不频繁，最后当电枢的运动与发电机的运动同步时，这种反转就停止了。在这种情况下，电动机的励磁铁芯和极靴仅仅是通过感应就变成了一个磁体。

I have found that advantageous results are secured by winding the field-magnets with a coil or coils and passing a continuous current through them, thus maintaining a permanent field, and in this feature my present invention consists.

我已经发现，通过用一个或多个线圈缠绕场磁体并使恒向电流通过它们，从而维持一个持久磁场，可以获得有利的结果，并且我的发明也包括这个特征。

I shall now describe the apparatus which I have devised for carrying out this invention and explain the mode of using or operating the same.

我现在将描述我为实施本发明而设计的装置，并解释使用或运行该装置的方式。

Figure 1 is an end view in elevation of my improved motor. Fig. 2 is a part horizontal central section, and Fig. 3 is a diagrammatic representation of the motor and generator combined and connected for operation.

图1是我的改进后的电动机的端视图。图2是一个部件的水平中心截面图，图3是电动机和发电机的组合和用于运行的连接的示意图。

Let A A in Fig. 1 represent the legs or pole-pieces of a field-magnet, around which are coils B B, included in the circuit of a continuous-current generator, C, which is adapted to impart magnetism to the said poles in the ordinary manner.

图1中的A A表示场磁体的腿或极靴，其周围是线圈B B，该线圈被包含在一个恒向电流发电机C的电路中，该电路适于以普通方式将磁性赋予所述磁极。

D D' are two independent coils wound upon a suitable cylindrical or equivalent armature-core, which, like all others used in a similar manner, should be split or divided up into alternate magnetic and insulating parts in the usual way. This armature is mounted in non-magnetic cross-bars E E, secured to

the poles of the field-magnet. The terminals of the armature-coils D D' are connected to insulated sliding contact-rings a a b b, carried by the armature shaft, and brushes c c' bear upon these rings to convey to the coils the currents which operate the motor.

D D'是缠绕在一个合适的圆柱形或等效电枢铁芯上的两个独立线圈，与所有其他以类似方式使用的线圈一样，应以通常方式分割或切割成交替的磁性和绝缘部分。这个电枢被安装在非磁性交叉杆 E E 上，该交叉杆被固定在场磁铁的磁极上。电枢线圈 D D'的终端连接到由电枢轴支撑的被绝缘的滑动接触环 a a b b 上，电刷 c c'压在这些环上，将驱动电动机的电流传送到线圈。

The generator for operating this motor is or may be of precisely identical construction; and for convenience of reference I have marked in Fig. 3 its parts, as follows: F F, the field-magnets, energized by a continuous current passing in its field-coils G G; H H', the coils carried by the cylindrical armature; d d e e, the friction or collecting rings, carried by the armature-shaft and forming the terminals of the armature-coils; and f f', the collecting-brushes which deliver the currents developed in the armature-coils to the two circuits g g', which connect the generators with the motor.

用于运行该电动机的发电机是或者可以是完全一致的结构；为了便于参考，我在图 3 中标记了它的部件，如下：F F，场磁铁，由通过它的励磁线圈 G G 的恒向电流所励磁；H H'，由圆柱形电枢携带的线圈；d d e e，摩擦环或集电环，由电枢轴携带，形成电枢线圈的终端；以及 f f'，集电刷，将电枢线圈中产生的电流传送到连接发电机和电动机的两个电路 g g'。

The operation of this system will be understood from the foregoing. The action of the generator, by causing a progressive shifting of the poles in the motor-armature, sets up in the latter a rotation opposite in direction to that in which the poles move. If, now, the continuous current be directed through the field-coils, so as to strongly energize the magnet A A, the speed of the motor, which depends upon that of the generator, will not be increased, but the power which produces its rotation will be increased in proportion to the energy supplied through the coils B B.

从前面的描述中可以理解该系统的操作。发电机的作用是使电动机电枢中的磁极逐渐转移，从而使电枢产生与磁极移动方向相反的旋转。现在，如果恒向电流通过磁场线圈，来强烈地励磁磁体 A A，取决于发电机的速度的电动机的速度不会增加，但产生电动机旋转的功率将与线圈 B B 提供的能量成正比例地增加。

It is characteristic of this motor that its direction of rotation is not reversed by reversing the direction of the current through its field-coils, for the direction of rotation depends not upon the polarity of the field, but upon the direction in which the poles of the armature are shifted. To reverse the motor, the connections of either of the circuits g g' must be reversed.

这种电动机的特点是，它的旋转方向不会因通过励磁线圈的电流方向的反转而反转，因为旋转方向不取决于磁场的极性，而是取决于电枢磁极移动的方向。要反转电动机，必须反转电路 g g'的任一连接。

I have found that if the field-magnet of the motor be strongly energized by its coils B B and the circuits through the armature-coils closed, assuming the generator to be running at a certain speed, the motor

will not start; but if the field be but slightly energized or in general in such condition that the magnetic influence of the armature preponderates in determining its magnetic condition the motor will start and, with sufficient current, will reach its maximum or normal speed. For this reason it is desirable to keep at the start and until the motor has attained its normal speed, or nearly so, the field-circuit open or to permit but little current to pass through it. I have found, however, if the fields of both the generator and motor be strongly energized that starting the generator starts the motor, and that the speed of the motor is increased in synchronism with the generator. Motors constructed and operated on this principle maintain almost absolutely the same speed for all loads within their normal working-limits; and in practice I have observed that if the motor be overloaded to such an extent as to check its speed the speed of the generator, if its motive power be not too great, is diminished synchronously with that of the motor.

我已发现，如果电动机的场磁体被它的线圈 B B 强烈励磁，并且通过电枢线圈的电路闭合，假设发电机以一定的速度运行，电动机将不会启动；但是，如果磁场只是轻微励磁，或者一般情况下，电枢的磁性影响在确定其磁性条件时占优势，电动机将启动，并在足够的电流下，将达到其最大速度或正常速度。由于这个原因，最好是在启动时保持励磁电路开路或者只允许很小的电流通过，直到电动机达到正常速度或接近正常速度。然而，我发现，如果发电机和电动机的磁场都被强烈激励，那么启动发电机就启动了电动机，并且电动机的速度与发电机同步增加。根据这一原理制造和运行的电动机，在其正常工作限度内，对所有负载都保持几乎绝对相同的速度；并且在实践中，我观察到，如果电动机过载到抑制其速度的程度，则发电机的速度（如果其动力不太大）将与电动机的速度同步减小。

I have in other applications shown how the construction of these or similar motors may be varied in certain well-known ways—as, for instance, by rotating the field about a stationary armature or rotating conductors within the field; but I do not illustrate these features further herein, as with the illustration which I have given I regard the rest as within the power of a person skilled in the art to construct.

我在其他应用中展示了这些或类似的电动机的结构如何以某些众所周知的方式变化——例如，通过围绕着一个静态电枢来旋转磁场，或旋转磁场内的导体；但是我在此不进一步说明这些特征，因为对于我已经给出的说明，我认为其余部分在本领域技术人员的能力范围内。

The present form of motor is cheap, simple, reliable, and easy to maintain. It requires the simplest type of generator for its operation, and when properly constructed shows a high efficiency.

目前形式的电动机便宜、简单、可靠且易于维护。它需要最简单的发电机来运行，如果构造得当，它会表现出很高的效率。

I do not claim herein the method of transmitting power which this system involves, having made it the subject of another application for patent.

我在此不对该系统所涉及的传输功率的方法提出主张要求，该方法已经使其成为另一专利申请的主题。

What I claim is—

我主张的是—

The combination, with a motor having independent energizing or armature circuits, of an alternating-current generator with corresponding induced circuits connected with the motor for effecting a progressive shifting of the poles of the motor-armature, and a source of continuous current for energizing the field of said motor, as set forth.

如上所述，一个交流发电机与具有独立的励磁电路或电枢电路的一个电动机的组合，该交流发电机具有与电动机连接的相应感应电路，用于实现电动机电枢磁极的渐进转移，以及用于激励所述电动机磁场的一个恒向电流电源。

NIKOLA TESLA.

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N. TESLA.

ELECTRO MAGNETIC MOTOR.

No. 381,969.

Patented May 1, 1888.

Fig: 1.

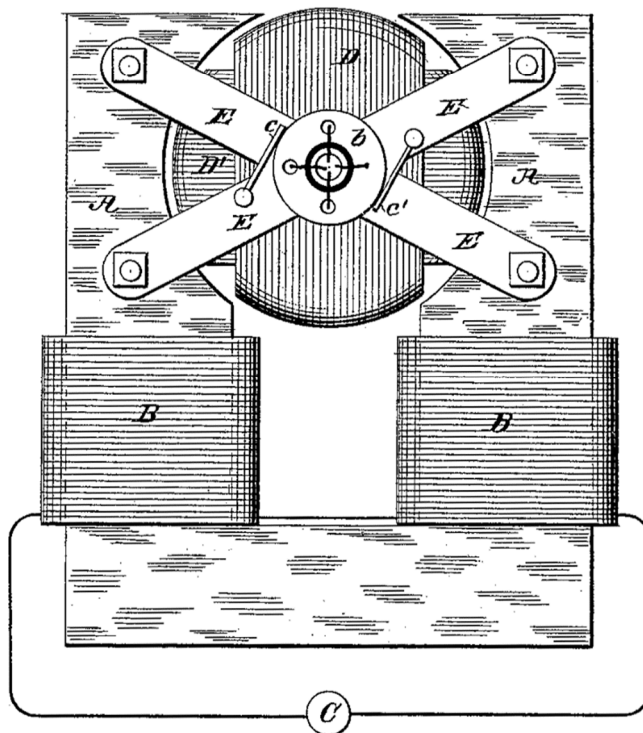
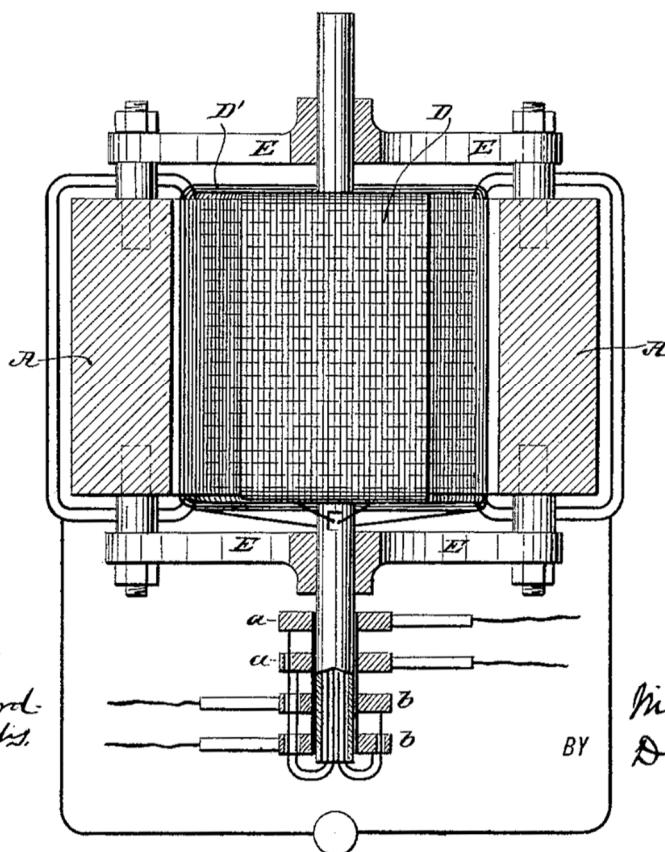


Fig: 2.



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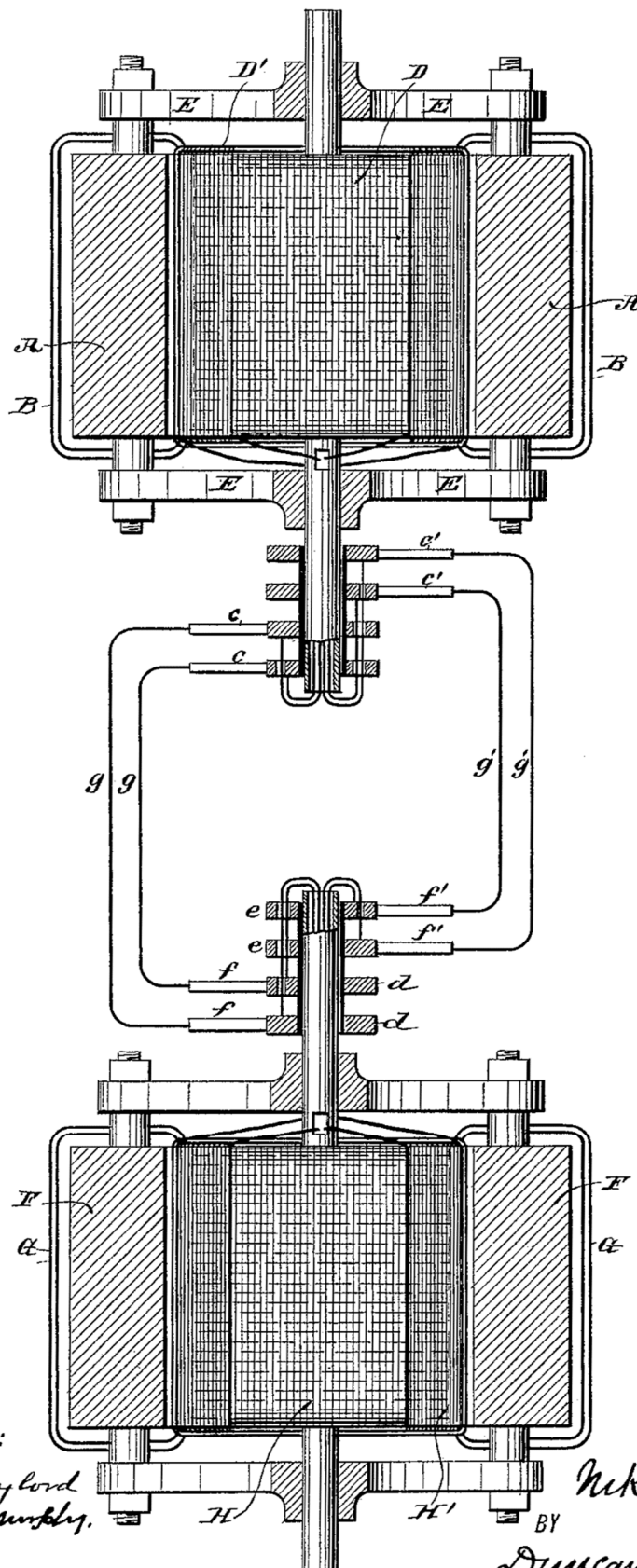
N. TESLA.

ELECTRO MAGNETIC MOTOR.

No. 381,969.

Patented May 1, 1888.

Fig: 3



WITNESSES:

Robert F. Gaylord
Frank B. Murphy.

INVENTOR.

Nikola Tesla
BY
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ATTORNEYS.

SYSTEM OF ELECTRICAL DISTRIBUTION.

配电系统

NIKOLA TESLA, OF NEW YORK, N.Y., ASSIGNOR OF ONE-HALF TO CHARLES F.
PECK, OF ENGLEWOOD, NEW JERSEY.

纽约州纽约市的尼古拉·特斯拉将一般专利权转让给
新泽西州恩格尔伍德市的查尔斯·F·佩克。

SPECIFICATION forming part of Letters Patent No. 381,970, dated May 1, 1888.

Application filed December 23, 1887. Serial No. 258,787. (No model.)

该说明书形成了颁发于 1888 年 5 月 1 日编号为 381,970 的专利证书的一部分。

申请于 1887 年 12 月 23 日提交。序列号为 258,787。(没有模型)

To all whom it may concern:

致所有相关人士:

Be it known that I, NIKOLA TESLA, from Smiljan Lika, border country of Austria-Hungary, now residing at New York, in the county and State of New York, have invented certain new and useful Improvements in Systems of Electrical Distribution, of which the following is a specification, reference being had to the drawings accompanying and forming a part of the same.

众所周知，我、尼古拉·特斯拉、一位奥匈帝国的臣民，来自奥匈帝国边境地区的利卡县的史密里安村，现在居住在纽约州纽约郡纽约市，在配电系统方面已经发明了某些新的和有用的改进，以下是该发明一个说明书，必须参考随附的图纸，它已形成该说明书的一部分。

The invention relates to those systems of electrical distribution in which a current from a single source of supply in a main or transmitting circuit is caused to induce by means of suitable induction apparatus a current or currents in an independent working circuit or circuits.

本发明涉及这样的配电系统，在这样的系统中，利用合适的感应装置使来自主电路或输电电路中的单个电源的电流在独立的工作电路中感应出一个或多个电流。

The main objects of the invention are the same as have been heretofore obtained by use of these systems—viz., to divide the current from a single source, whereby a number of lamps, motors, or other translating devices may be independently controlled and operated by the same source of current, and in some cases to reduce a current of high potential in the main circuit to one of greater quantity and lower potential in the independent consumption or working circuit or circuits.

本发明的主要目的与迄今为止通过使用这些系统获得的目的相同——即分配来自单个电源的电流，由此多个电灯、电动机或其他转换装置可以由同一个电流源独立控制和运行，并且在一些情况下，可以将主电路中的一个高电位电流减小到在独立的消耗电路或工作电路中的

较大量和较低电位这二者中的一种。

The general character of the devices employed in these systems is now well understood. An alternating-current magneto-machine is used as the source of supply. The current developed thereby is conducted through a transmission-circuit to one or more distant points at which the transformers are located. These consist of induction-machines of various kinds. In some cases ordinary forms of induction-coil have been used with one coil in the transmitting-circuit and the other in a local or consumption circuit, the coils being differently proportioned according to the work to be done in the consumption-circuit—that is to say, if the work requires a current of higher potential than that in the transmission-circuit the secondary or induced coil is of greater length and resistance than the primary, while, on the other hand, if a quantity current of lower potential is wanted the longer coil is made the primary. In lieu of these devices various forms of electro-dynamic induction-machines, including the combined motors and generators, have been devised. For instance, a motor is constructed in accordance with well understood principles, and on the same armature are wound induced coils which constitute a generator. The motor-coils are generally of fine wire and the generator-coils of coarser wire, so as to produce a current of greater quantity and lower potential than the line-current, which is of relatively high potential, to avoid loss in long transmission. A similar arrangement is to wind coils corresponding to those described in a ring or similar core, and by means of a commutator of suitable kind to direct the current through the inducing-coils successively, so as to maintain a movement of the poles of the core and of the lines of force which set up the currents in the induced coils.

这些系统中使用的设备的一般特性现在已经很好理解了。一个交流磁电机被用作一个电源。由此产生的电流通过一个传输电路被传导到变压器所在的一个或多个远点。这些包括各种各样的感应机器。在某些情况下，使用普通形式的感应线圈，一个线圈在传输电路中，另一个线圈在本地或消耗电路中，这些线圈根据消耗电路中要做的工作而成不同的比例，也就是说，如果工作需要比传输电路中的电流更高电势的电流，则次级或感应线圈比初级线圈具有更大的长度和电阻，而另一方面，如果需要较低电势的电流量，则较长的线圈被制成初级线圈。已经设计出各种形式的电动感应电机器来代替这些装置，包括组合式电动机和发电机。例如，一个电动机是根据众所周知的原理构建的，在同一个电枢上缠绕着构成发电机的感应线圈。电动机线圈通常由细导线制成，而发电机线圈由粗导线制成，以便产生比线路电流更大电流量和更低电势的电流，线路电流具有相对较高的电势，以避免长距离传输中的损耗。一个类似的布置是缠绕对应于在一个环形铁芯或类似的铁芯中的描述过的那些线圈，并且借助于合适种类的一个换向器来引导电流相继通过感应线圈，以便保持铁芯的磁极的一个运动和在感应线圈中建立电流的磁力线的一个运动。

Without enumerating the objections to these systems in detail, it will suffice to say that the theory or the principle of the action or operation of these devices has apparently been so little understood that their proper construction and use have up to the present time been attended with various difficulties and great expense. The transformers are very liable to be injured and burned out, and the means resorted to for curing this and other defects have almost invariably been at the expense of efficiency.

没有详细列举对这些系统的缺点，可以说这些装置的作用或运行的理论或原理显然很少被理解，以至于它们的正确的构建和使用遇到了各种困难和花费了巨大的费用。变压器很容易被损坏和烧毁，为解决这一缺陷和其他缺陷而采取的措施几乎总是以牺牲效率为代价。

The form of converter or transformer which I have devised appears to be largely free from the defects and objections to which I have alluded. While I do not herein advance any theory as to its mode of operation, I would state that, in so far as the principle of construction is concerned, it is analogous to those transformers which I have above described as electro-dynamic induction-machines, except that it involves no moving parts whatever, and is hence not liable to wear or other derangement, and requires no more attention than the other and more common induction-machines.

我设计的转换器或变压器的形式似乎很大程度上没有我提到的缺陷和缺点。虽然我在此不就其工作模式提出任何理论，但我要说明的是，就结构原理而言，它类似于我在上面描述为电动感应电机的那些变压器，除了它不涉及任何可移动部件，因此不容易磨损或遇到其他紊乱，并且不需要比其他更常见的感应电机更多的关注。

In carrying out my invention I provide a series of inducing-coils and corresponding induced coils, which, by preference, I wind upon a core closed upon itself—such as an annulus or ring subdivided in the usual manner. The two sets of coils are wound side by side or superposed or otherwise placed in well-known ways to bring them into the most effective relations to one another and to the core. The inducing or primary coils wound on the core are divided into pairs or sets by the proper electrical connections, so that while the coils of one pair or set to co-operate in fixing the magnetic poles of the core at two given diametrically-opposite points, the coils of the other pair or set—assuming, for sake of illustration, that there are but two—tend to fix the poles ninety degrees from such points. With this induction device I use an alternating-current generator with coils or sets of coils to correspond with those of the converter, and by means of suitable conductors I connect up in independent circuits the corresponding coils of the generator and converter. It results from this that the different electrical phases in the generator are attended by corresponding magnetic changes in the converter; or, in other words, that as the generator-coils revolve the points of greatest magnetic intensity in the converter will be progressively shifted or whirled around. This principle I have applied under variously-modified conditions to the operation of electro-magnetic motors, and in previous applications, notably in those having Serial Nos. 252,132 and 256,561, I have described in detail the manner of constructing and using such motors. In the present application my object is to describe the best and most convenient manner of which I am at present aware of carrying out the invention as applied to a system of electrical distribution; but one skilled in the art will readily understand from the description by the modifications proposed in said applications, wherein the form of both the generator and converter in the present case may be modified.

在实施我的发明时，我提供了一系列施感线圈和相应的感应线圈，首选地，我将线圈缠绕在一个自身闭合的铁芯上——例如以通常方式细分的环或圈。这两组线圈并排缠绕或重叠，或者以众所周知的方式放置，以使得它们彼此之间以及与铁芯之间形成最有效的关系。缠绕在铁芯上的施感线圈或初级线圈通过适当的电连接分成线圈对或线圈组，从而当一个线圈对或一个线圈组合作将铁芯的磁极固定在两个给定的径向相对的点上时，另一个线圈对或线圈组——为了便于说明，假设只有两对——倾向于将磁极固定在与这些点成 90 度的位置上。对于这种感应装置，我使用带有线圈或线圈组的交流发电机与转换器的线圈或线圈组相对应，并通过合适的导体将发电机和转换器的相应线圈连接在独立的电路中。由此导致发电机中不同的电相位伴随着转换器中相应的磁变化；或者，换句话说，随着发电机线圈旋转，转换器中最大磁场强度的点将逐渐转移或旋转。我已经在各种修改的条件下将该原理应用于电磁电动机的运行，并且在以前的申请中，特别是在序列号为 252,132 和 256,561 的申请中，我已经

详细描述了构建和使用这种电动机的方式。在本申请中，我的目的是描述我目前所知的实施本发明应用于配电系统的最佳和最方便的方式；但是本领域的技术人员将通过在所述申请中提出的修改从描述中容易地理解，其中在当前情况下发电机和转换器的形式都可以被修改。

In illustration therefore of the details of construction which my present invention involves, I now refer to the accompanying drawings.

因此，为了说明本发明所涉及的结构细节，我现在参照附图。

Figure 1 is a diagrammatic illustration of the converter and the electrical connections of the same. Fig. 2 is a horizontal central cross-section of Fig. 1. Fig. 3 is a diagram of the circuits of the entire system, the generator being shown in section.

图 1 是转换器及其电连接的示意图。图 2 是图 1 的水平中心截面图。图 3 是整个系统的电路图，发电机以截面展示。

I use a core, A, which is closed upon itself—that is to say, of an annular cylindrical or equivalent form—and as the efficiency of the apparatus is largely increased by the subdivision of this core I make it of thin strips, plates, or wires of soft iron electrically insulated as far as practicable. Upon this core, by any well-known method, I wind, say, four coils, B B' B', which I use as primary coils, and for which I use long lengths of comparatively fine wire. Over these coils I then wind shorter coils of coarser wire, C C' C', to constitute the induced or secondary coils. The construction of this or any equivalent form of converter may be carried further, as above pointed out, by inclosing these coils with iron—as, for example, by winding over the coils a layer or layers of insulated iron wire.

我使用一个铁芯 A，它本身是闭合的——也就是说，一个环形的圆柱或等效的形式——并且由于该铁芯的细分大大提高了设备的效率，因此我将其尽可能地用电绝缘的软铁薄条、板或线来制成铁芯 A。我通过任何众所周知的方法在这个铁芯上缠绕了四个线圈，比如说，B B' B'，我将它们用作初级线圈，并且使用了大长度的相对较细的导线。在这些线圈上，我用较粗的导线绕制了较短的线圈 C C' C'，以构成感应线圈或次级线圈。如上所述，通过用铁包围这些线圈，例如通过在线圈上缠绕一层或多层被绝缘的铁丝，可以进一步实现转换器的这种构造或任何等效形式。

The device is provided with suitable binding-post, to which the ends of the coils are led. The diametrically-opposite coils B B and B' B' are connected, respectively, in series, and the four terminals are connected to the binding-posts 1 2 3 4. The induced coils are connected together in any desired manner. For example, as shown in Fig. 3, C C may be connected in multiple arc when a quantity current is desired—as for running a group of incandescent lamps, D—while C' C' may be independently connected in series in a circuit including arc lamps or the like. The generator in this system will be adapted to the converter in the manner illustrated. For example, in the present case I employ a pair of ordinary permanent or electro magnets, E E, between which is mounted a cylindrical armature on a shaft, F, and wound with two coils, G G'. The terminals of these coils are connected, respectively, to four insulated contact or collecting rings, H H H' H', and the four line circuit-wires L connect the brushes K, bearing on these rings, to the converter in order shown. Noting the results of this combination, it will be observed that at a given point of time the coil G is in its neutral position and is

generating little or no current, while the other coil, G', is in a position where it exerts its maximum effect. Assuming coil G to be connected in circuit with coils B B of the converter, and coil G' with coils B' B', it is evident that the poles of the ring A will be determined by coils B' B' alone; but as the armature of the generator revolves, coil G develops more current and coil G' less, until G reaches its maximum and G' its neutral position. The obvious result will be to shift the poles of the ring A through one-quarter of its periphery. The movement of the coils through the next quarter of a turn, during which coil G' enters a field of opposite polarity and generates a current of opposite direction and increasing strength, while coil G, in passing from its maximum to its neutral position generates a current of decreasing strength and same direction as before, causes a further shifting of the poles through the second quarter of the ring. The second half-revolution will obviously be a repetition of the same action. By the shifting of the poles of the ring A a powerful dynamic inductive effect on the coils C C' is produced. Besides the currents generated in the secondary coils by dynamo-magnetic induction other currents will be set up in the same coils in consequence of any variations in the intensity of the poles in the ring A. This should be avoided by maintaining the intensity of the poles constant, to accomplish which care should be taken in designing and proportioning the generator and in distributing the coils in the ring A, and balancing their effect. When this is done, the currents are produced by dynamo-magnetic induction only, the same result being obtained as though the poles were shifted by a commutator with an infinite number of segments.

该装置配有合适的接线柱，线圈的端部被引导到该接线柱。径向相对的线圈 B B 串联连接，径向相对的线圈 B' B' 串联连接，并且四个端子连接到接线柱 1 2 3 4。感应线圈以任何需要的方式连接在一起。例如，如图 3 所示，当需要一定量的电流时，C C' 可以以多弧方式连接，如运行一组白炽灯 D——而 C' C' 可以独立地串联在包含弧光灯等负载的电路中。该系统中的发电机将以图示的方式适用于转换器。例如，在目前的情况下，我使用一对普通的永磁体或电磁体 E E，在它们之间在一个轴 F 上安装一个圆柱形电枢，并缠绕上两个线圈 G G'。这些线圈的终端分别连接到四个被绝缘的接触环或集电环 H H H' H' 上，并且四条线路的电路导线 L 把倚靠在这些环上的电刷 K 按所示顺序连接到转换器上。注意这种组合的结果，将会观察到，在给定的时间点，线圈 G 处于其中性位置并且产生很少电流或没有电流，而另一个线圈 G' 处于发挥其最大效果的位置。假设线圈 G 在电路中与转换器的线圈 B B 连接，并且线圈 G' 与线圈 B' B' 连接，显然，环 A 的极点将仅由线圈 B' B' 确定；但是当发电机的电枢旋转时，线圈 G 产生更多的电流，而线圈 G' 产生更少的电流，直到 G 达到最大值，并且 G' 处于中性位置。明显的结果是环 A 的极点将移动经过其外围的四分之一。线圈通过下一个四分之一圈的运动，在此期间，线圈 G' 进入相反极性的磁场，并产生相反方向的且强度增强的电流，而线圈 G 在从其最大值到其中性位置的过程中，产生强度减小且方向与之前相同的电流，这导致磁极进一步转移并通过环的第二个四分之一圈。第二次半圈显然是同一动作的重复。通过环 A 磁极的转移，在线圈 C C' 上产生一个强大的动态感应效应。除了由电动机的发电机-磁感应在次级线圈中产生的电流之外，由于环 A 中磁极强度的任何变化，在上述线圈中将产生其它电流。应通过保持磁极强度不变来避免这种情况，为此，在设计和均衡发电机以及在环 A 中分配线圈和平衡它们的效果时应小心谨慎。当这样做时，电流仅由发电机-磁感应产生，获得的结果相同，所获得的结果就好像这些磁极被一个具有无限数量分段的换向器转移了一样。

The modifications which are applicable to other forms of converter are in many respects applicable to this. I refer more particularly to the form of the core, the relative lengths and resistances of the primary and secondary coils, and the arrangements for running or operating the same.

适用于其他形式的转换器的修改在许多方面也适用于此。更具体地说,我指的是铁芯的形式、初级线圈和次级线圈的相对长度和电阻,以及运行或操作它们的布置。

The new method of electrical conversion which this system involves I have made the subject of another application, and I do not claim it therefore herein.

该系统所涉及的新的电转换方法已经成为另一个申请的主题,因此我在此不主张该项权利。

Without limiting myself therefore to any specific form, what I claim is—

因此,我并不局限于任何特定的形式,我所主张是—

1. The combination, with a core closed upon itself, inducing or primary coils wound thereon and connected up in independent pairs or sets, and induced or secondary coils wound upon or near the primary coils, of a generator of alternating currents and independent connections to the primary coils, whereby by the operation of the generator a progressive shifting of the poles of the core is effected, as set forth.

1、存在一个组合,它包括:一个自身闭合的铁芯;在该铁芯上缠绕的施感线圈或初级线圈并连接成独立的线圈对或组;在该铁芯上缠绕或靠近初级线圈的感应线圈或次级线圈;一个交流发电机和初级线圈的独立连接,由此通过发电机的操作实现铁芯磁极的渐进转移,如上所述。

2. The combination, with an annular or similar magnetic core and primary and secondary coils wound thereon, of an alternating-current generator having induced or armature-coils corresponding to the primary coils, and independent circuits connecting the primary coils with the corresponding coils of the generator, as herein set forth.

2、存在一个组合,它包括:一个环形的或者类似的磁芯,并且初级线圈和次级线圈缠绕其上;具有对应于初级线圈的感应线圈或电枢线圈的交流发电机;将初级线圈与发电机的相应线圈连接起来的独立电路,如本文所述。

3. The combination, with independent electric transmission-circuits, of transformers consisting of annular or similar cores wound with primary and secondary coils, the opposite primary coils of each transformer being connected to one of the transmission-circuits, an alternating-current generator with independent induced or armature coils connected with the transmission-circuits, whereby alternating currents may be directed through the primary coils of the transformers in the order and manner herein described.

3、存在一个组合,它包括:独立的电力传输电路;由缠绕有初级线圈和次级线圈的环形或类似铁芯组成的变压器;连接到传输电路之一的每个变压器的径向相对初级线圈;具有与传输电路连接的独立感应线圈或电枢线圈的交流发电机,由此交流电可以以这里描述的顺序和方式被引导通过变压器的初级线圈。

NIKOLA TESLA.

尼古拉·特斯拉

Witnesses:

ROBT. H. DUNCAN,

ROBT. F. GAYLORD.

见证人:

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N. TESLA.

SYSTEM OF ELECTRICAL DISTRIBUTION.

No. 381,970.

Patented May 1, 1888.

Fig. 1.

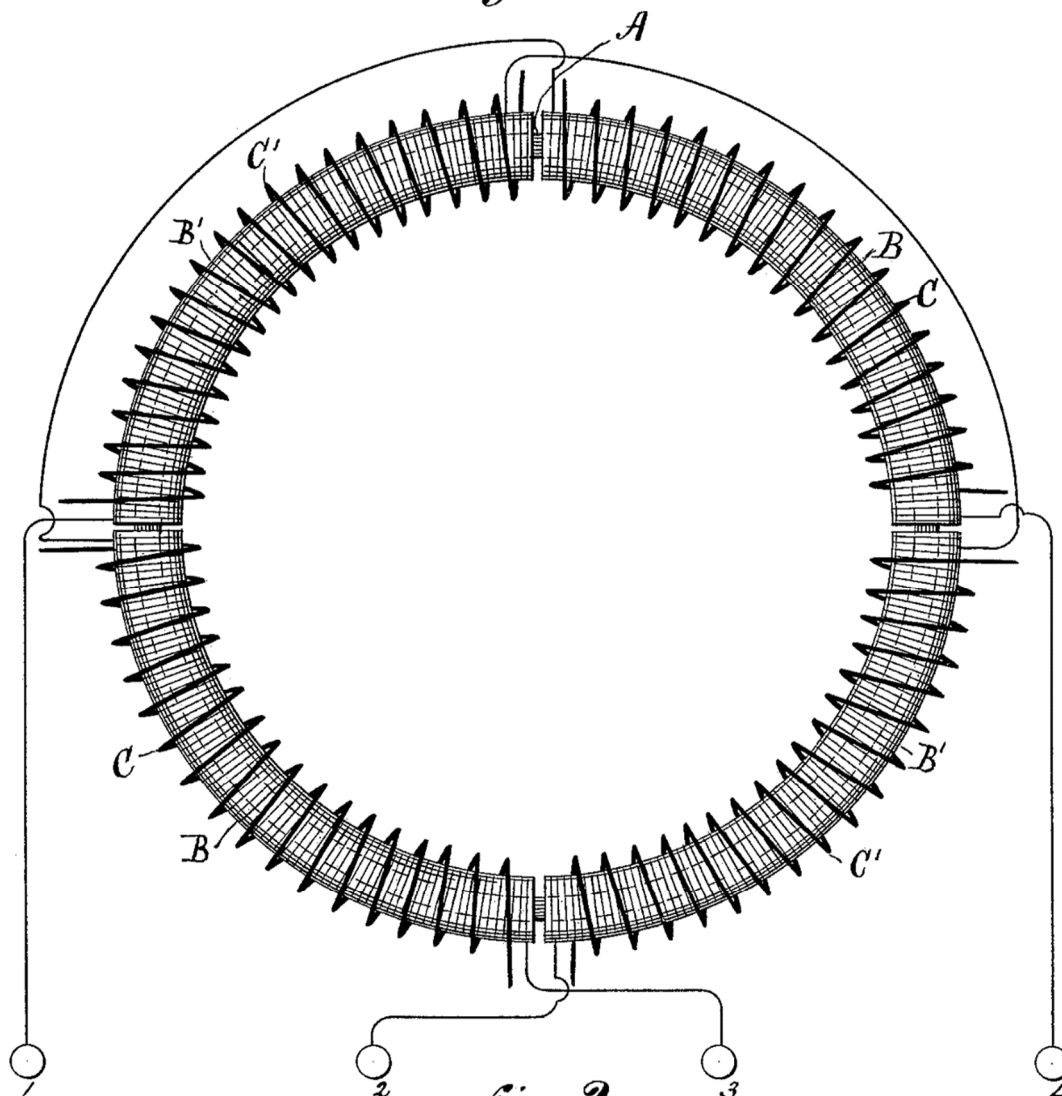
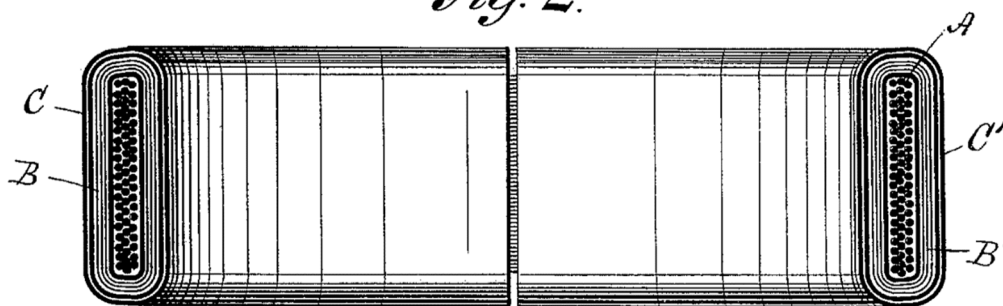


Fig. 2.



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Robt. F. Gaylord

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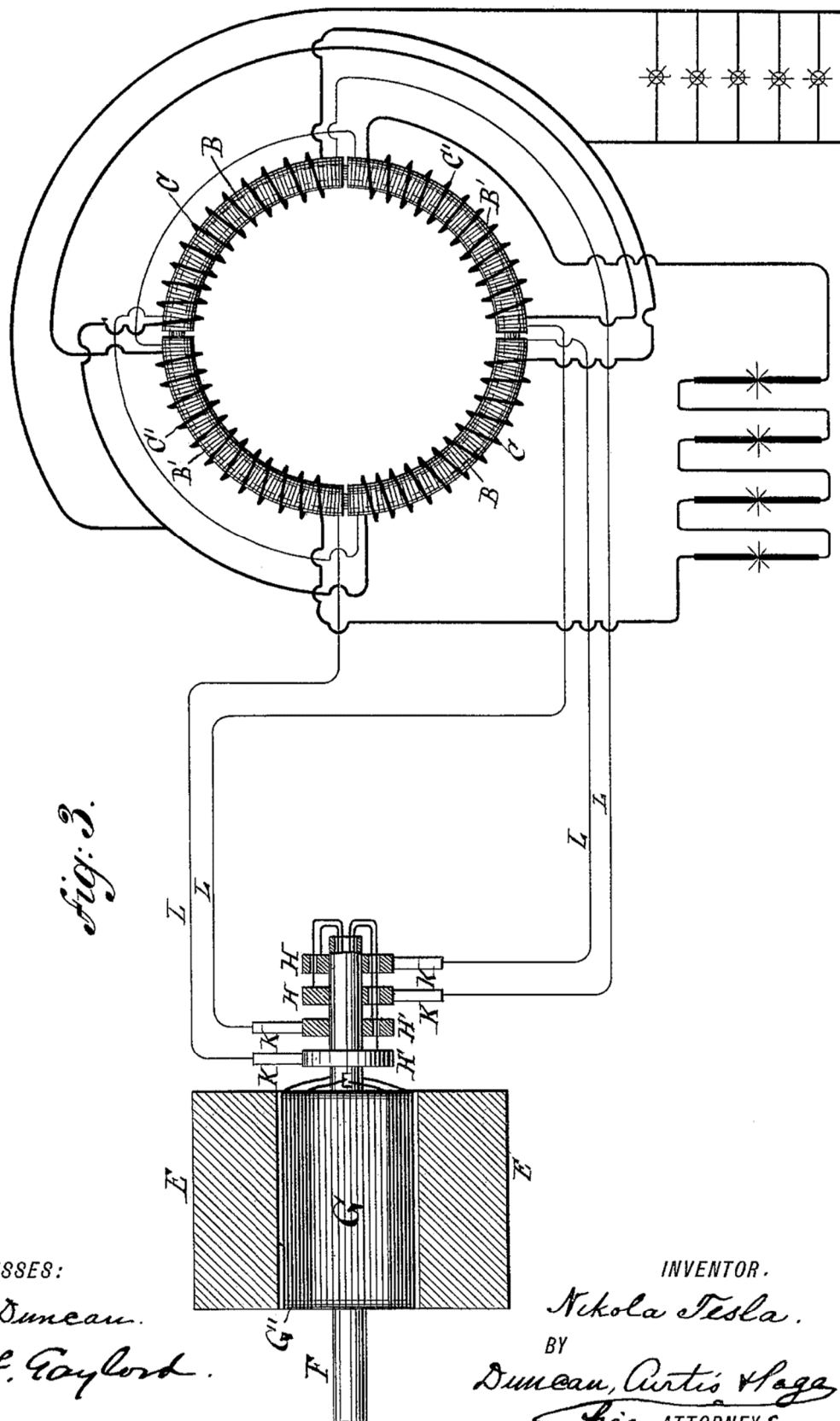
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ELECTRO-MAGNETIC MOTOR.

电磁电动机

NIKOLA TESLA, OF NEW YORK, ASSIGNOR OF ONE-HALF TO CHARLES F. PECK, OF
ENGLEWOOD, NEW JERSEY.

纽约市的尼古拉·特斯拉将一半专利权转让给新泽西州
恩格尔伍德市的查尔斯·F·佩克

SPECIFICATION forming part of Letters Patent No. 382,279, dated May 1, 1888.

Application filed November 30, 1887. Serial No. 256,561. (No model.)

该说明书形成了颁发于 1888 年 5 月 1 日编号为 382,279 的专利证书的一部分。

申请于 1887 年 11 月 30 日提交。序列号为 256,561。(没有模型)

To all whom it may concern:

致所有相关人士:

Be it known that I, NIKOLA TESLA, a subject of the Emperor of Austria, from Smiljan, Lika, border country of Austria-Hungary, now residing at New York, in the county and State of New York, have invented certain new and useful Improvements in Electro-Magnetic Motors, of which the following is a specification, reference being had to the drawings accompanying and forming a part of the same.

众所周知，我、尼古拉·特斯拉、一位奥匈帝国的臣民，来自奥匈帝国边境地区的利卡县的史密里安村，现在居住在纽约州纽约郡纽约市，在电磁电动机方面已经发明了某种新的和有用的改进，以下是该发明一个说明书，必须参考随附的图纸，它已形成该说明书的一部分。

In a former application, filed October 12, 1887, No. 252,132, I have shown and described a mode or plan of operating electric motors by causing a progressive shifting of the poles of one or both of the parts or elements of a motor—that is to say, of either the field magnet or magnets or armature, or both. I accomplish this by constructing a motor with two or more independent energizing-circuits, on the field-magnets, for example, and I connect these up with corresponding induced or generating circuits in an alternating-current generator, so that alternating currents are caused to traverse the motor-circuits. By so doing the poles of the field-magnet of the motor are progressively shifted, and by their attraction upon a rotary armature set up a rotation in the latter in the direction of the movement of the poles. In this case, however, the rotation is produced and maintained by the direct attraction of the magnetic elements of the motor. I have discovered that advantageous results may be secured in this system by utilizing the shifting of the poles primarily to set up currents in a closed conductor located within the influence of the field of the motor, so that the rotation may result from the reaction of such currents upon the field.

在 1887 年 10 月 12 日提交的第 252,132 号的早期申请中，我已经展示并描述了一种通过使电动机的一个或两个部件或组件（也就是说，场磁体或磁体或电枢，或者两者兼而有之）的磁

极逐渐移动来操作电机的模式或方案。我通过构建一个具有两个或多个独立励磁电路的电动机来达到这一点，例如，在场磁体上，我将这些相应的感应电路或发电电路连接到交流发电机上，从而使得交流电穿过电动机电路。通过这样做，电动机的场磁体的磁极逐渐转移，并且通过它们施加在一个旋转电枢上的吸引，在后者中建立了一个沿磁极移动方向的旋转。然而，在这种情况下，旋转是通过电动机的磁性组件的直接吸引来产生和维持的。我已经发现，通过利用磁极的转移，可以在该系统中获得有利的结果，主要是在位于电动机磁场影响范围内的一个闭合导体中建立电流，使得旋转可以由这种电流对磁场的反作用产生。

To illustrate more fully the nature of the invention I refer to the accompanying drawings.

为了更充分地说明本发明的本质，我参考附图。

Figure 1 represents in side elevation the operative parts or elements of a motor embodying the principles of my invention, and in section the generator for operating the same. Fig. 2 is a horizontal central section of the motor in Fig. 1, the circuits being shown partly in diagram. Fig. 3 is a modified form of motor in side elevation. Fig. 4 is a central horizontal cross-section of Fig. 3.

图 1 以侧视图展示了体现本发明原理的电动机的运行部件或组件，并以截面图展示了用于操作该电动机的发电机。图 2 是图 1 中电动机的一个中心水平截面图，部分电路在图中示出。图 3 是电动机的改进形式的侧视图。图 4 是图 3 的中心水平截面图。

In Figs. 1 and 2, A is an annular core of soft iron, preferably laminated or formed of insulated sections, so as to be susceptible to rapid variations of magnetism. This core is wound with four coils, C C C' C', the diametrically-opposite coils being connected in the same circuit, and the two free ends of each pair being brought to the terminals t and t', respectively, as shown. Within this annular field-magnet A is mounted a soft-iron cylinder or disk, D, on an axis, a, in bearings b b, properly supported by the framework of the machine. The disk carries two coils, E E', of insulated wire, wound at right angles to another, and having their respective ends joined, so that each coil forms a separate closed circuit.

在图 1 和图 2 中，A 是的一个环形软铁芯，最好由绝缘区段层叠或组成，以便易于受到磁性快速变化的影响。该铁芯缠绕有四个线圈 C C C' C'，径向相对的线圈在同一电路中连接，并且每对线圈的两个游离端分别连接到终端 t 和 t'，如图所示。在这个环形场磁铁 A 内安装一个软铁圆柱或圆盘 D，在轴 a 上，在轴承 b b 中，由机器的框架适当支撑。圆盘上有两个绝缘导线线圈 E E'，相互成直角缠绕，两端分别相连，这样每个线圈形成一个独立的闭合电路。

In illustration of the action or mode of operation of this apparatus, let it be assumed that the annular field-magnet A is permanently magnetized, so as to present two free poles diametrically opposite. If suitable mechanical provision be now made for rotating the field-magnet around the disk, the apparatus exemplifies the conditions of an ordinary magneto-generator, and currents would be set up in the coils or closed conductors E E' on the disk D. Evidently these currents would be the most powerful at or near the points of the greatest density of the lines of force, and they would, as in all similar cases, tend, at least theoretically, to establish magnetic poles in the disk D at right angles to those in the annular field-magnet A. As a result of the well-known reaction of these polarities upon each other, a more or less powerful tendency in the disk to rotate in the same direction as that of the field-magnet would be established. If, on the other hand, the ring or annular field-magnet A be held stationary and its magnetic

poles progressively shifted by passing through its coils C C' properly-alternated currents, it is obvious that similar results will follow, for the passage of the currents causing the shifting or whirling of the poles of the field-magnet A induces currents in the closed circuits of the armature coils E E', with the result of setting up a rotation of the disk D in the same direction of such shifting. Inasmuch as the currents are always induced or generated in the coils E E' in the same manner, the poles of the disk or cylinder follow continuously the poles of the annular field-magnet, maintaining, at least theoretically, the same relative position. This results in an even and perfect action of the apparatus.

为了说明该装置的动作或运行模式，假设环形场磁体 A 被永久磁化，从而呈现两个完全相反的自由磁极。如果现在为了围绕圆盘旋转场磁体而提供合适的机械装置，则用该设备举例说明普通发电机的条件，并且将在圆盘 D 上的线圈或闭合导体 E E' 中建立电流。显然，这些电流在力线密度最大的点处或附近处是最强大的，并且与所有类似的情况一样，它们倾向于，至少在理论上，在磁盘 D 中建立与环形磁场 A 中的磁极成直角的磁极。由于众所周知的这些极性相互作用的一个结果，将会在圆盘中建立一个或多或少的强有力的趋势，即圆盘的旋转方向与场磁铁的旋转方向相同。另一方面，如果环形场磁体 A 保持静止，并且通过使适当交变的电流流过其线圈 C C'，其磁极逐渐转移，显然将会出现类似的结果，因为引起场磁体 A 的磁极发生转移或旋转的电流的流过可以在电枢线圈 E E' 的闭合电路中感应出电流，其结果是使得圆盘 D 在与这种转移的相同方向上旋转。因为电流总是以相同的方式在线圈 E E' 中感应或产生，所以圆盘或圆柱的磁极连续地跟随环形场磁体的磁极，至少在理论上保持相同的相对位置。这导致设备的平稳和完美的动作。

In order that the system as a whole may be better understood, I shall now describe the mode or plan devised by me for producing the currents that effect the progressive shifting of the poles of the motor.

为了系统作为一个整体可以更好地理解，我现在将描述我设计的模式或方案，它能产生引起电动机的磁极发生渐进转移的电流。

In Fig. 1, B B' are the poles or pole-pieces of an alternating-current generator. They are permanently magnetized and of opposite polarity. F is a cylindrical or other armature containing the independent coils G G'. These coils are wound at right angles, so that while one is crossing the strongest portion of the field or force the other is at the neutral point. The coils G G' terminate in the two pairs of insulated collecting-rings f and f', upon which bear the brushes g g'. Four wires connect the motor-terminals t and t' with the brushes g and g', respectively. When the generator is rotated, the coil G will at the certain point shown in the drawings be generating its maximum current, while coil G' is neutral. Let it be assumed that this current is conveyed from the rings f f' to the terminals t t' and through the coils C C. Its effect will be to establish poles in the ring midway between the two coils. By the further rotation of the generator the coil G' is brought within the influence of the field and begins to produce a current, which grows stronger as the said coil approaches the maximum points of the field, while the current produced in the coil G diminishes as the said coil recedes from those points. The current from the coil G', being conveyed to the terminals t' t' and through coils C' C', has a tendency to establish poles at right angles to those set up by the coils C C; but owing to the greater effect of the current in coils C C the result is merely to advance the poles from the position in which they would remain if due to the magnetizing influence of coils C C alone. This progression continues for a quarter-revolution, until coil G G becomes neutral and coil G' G' produces its maximum current. The action described is then repeated, the poles having been shifted through one-half of the field, or a half-revolution. The second

half-revolution is accomplished in a similar way, the same polarity being maintained in the shifting poles by the movement of the generator-coils alternately through fields of opposite polarity.

在图 1 中, B B' 是交流发电机的磁极或极片。它们被永久磁化, 并且极性相反。F 是一个包含了独立线圈 G G' 的圆柱或其他电枢。这些线圈以直角排列缠绕, 因此当一个线圈穿过磁场或力的最强部分时, 另一个线圈处于中性点。线圈 G G' 终止于两对被绝缘的集电环 f 和 f', 集电环上倚靠着电刷 g g'。四根导线分别将电动机终端 t 和 t' 与电刷 g 和 g' 连接起来。当发电机旋转时, 线圈 G 将在图中所示的某一点产生其最大电流, 而线圈 G' 是中性的。假设该电流从环 f f' 传送到终端 t t', 并通过线圈 C C', 其效果将是在两个线圈中间的环中建立磁极。通过发电机的进一步旋转, 线圈 G 被带入磁场的影响范围内, 并开始产生电流, 当所述线圈接近磁场的最大点时, 该电流变得更强, 而当所述线圈远离这些点时, 线圈 G 中产生的电流减弱。从线圈 G' 传送到终端 t' t' 并通过线圈 C' C' 的电流具有建立与线圈 C C' 建立的磁极成直角的磁极的倾向; 但是由于线圈 C C' 中的电流的更大影响, 结果仅仅是将磁极从如果仅由于线圈 C C' 的磁化影响而使它们将要保持的位置向前推进。这个过程持续四分之一圈, 直到线圈 G G' 变得中性, 并且线圈 G' G' 产生了它的最大电流。然后重复所描述的动作, 磁极转移通过磁场的一半, 或半圈。第二个半圈也以类似的方式完成, 利用交替穿过相反极性的磁场的发电机线圈的运动, 在转移中的磁极中保持相同的极性。

The same principle of operation may be applied to motors of various forms, and I have shown one of such modified forms in Figs. 3 and 4 of the drawings. In these figures, M M' are field-magnets secured to or forming part of a frame, F', mounted on a base, P. These magnets should be laminated or composed of a number of electrically-insulated magnetic sections, to prevent the circulation of induced currents and to render them capable of rapid magnetic changes. These magnetic cores or poles are wound with insulated coils C C', the diametrically-opposite coils being connected together in series and their free ends brought to terminals t t', respectively. Between the poles there is mounted, in bearings in the cross-pieces G'', a cylindrical iron core, D, which, in order to prevent the formation of eddy currents, and the loss consequent thereon, is subdivided in the usual way. Insulated conductors or coils are applied to the cylinder D longitudinally, and for these I may employ copper plates E E', which are secured to the sides and ends of the cylindrical core in well known ways. These plates or conductors may form one or preferably several independent circuits around the core. In the drawings two of such circuits are shown, formed respectively by the conductors E and E', which are insulated from each other. It is advantageous also to slot these plates longitudinally, to prevent the formation of eddy currents and waste of energy.

相同的工作原理可以应用于各种形式的电动机, 我已经在图 3 和图 4 中展示了这种改进形式中的一种。在这些图中, M M' 是被固定到安装在底座 P 上的框架 F' 上的场磁体或形成框架 F' 的一部分的场磁体。这些磁体应由许多被绝缘的磁性截面进行层叠或组成, 以防止感应电流的环流, 并使其能够快速改变磁性。这些磁芯或磁极被缠绕有绝缘线圈 C C', 径向相对的线圈串联在一起, 并且它们的游离端分别连接到终端 t t'。在磁极之间, 在十字件 G'' 中的轴承中安装有圆柱形铁芯 D, 为了防止涡流的形成以及由此产生的损耗, 铁芯 D 以通常的方式被细分。被绝缘的导体或线圈纵向应用于圆柱 D, 为此, 我可以使用铜板 E E', 它以众所周知的方式被固定到圆柱铁芯的侧面和端部。这些板或导体可以在铁芯周围形成一个或最好几个独立的电路。在附图中, 展示了两个这样的电路, 分别由彼此绝缘的导体 E 和 E' 形成。纵向开槽这些板也是有利的, 以防止涡流的形成和能量的浪费。

From what has now been given the operation of this apparatus will be readily understood. To the binding-post $t\ t'$ are connected the proper circuits from the generator to cause a progressive shifting of the resultant magnetic poles produced by the magnets M upon the armature. Thus currents are induced in the closed circuits on the core, which, energizing the core strongly, maintain a powerful attraction between the same and the field, which causes a rotation of the armature in the direction in which the resultant poles are shifted. The particular advantage of the construction illustrated in Figs. 3 and 4 is that a concentrated and powerful field is obtained and a remarkably powerful tendency to rotation in the armature secured. The same results may be obtained in the form illustrated in Figs. 1 and 2, however, by forming polar projections on the field and armature-cores.

根据现在已经给出的内容，将容易理解该设备的操作。发电机的适当电路连接到接线柱 $t\ t'$ 上，以使电枢上的磁体 M 产生一个逐渐转移的合成磁极。因此，在铁芯上的闭合电路中感应出电流，该电流强烈地励磁铁芯，在铁芯和磁场之间维持着强大的吸引力，这导致电枢在合成磁极的转移方向上旋转。图 3 和图 4 中所示的结构的特别优点是获得了一个集中而强大的磁场，并保证了电枢中非常强的旋转趋势。然而，在图 1 和图 2 所示的形式中，通过在场和电枢铁芯上形成极突，可以获得相同的结果。

When these motors are not loaded, but running free, the rotation of the armature is nearly synchronous with the rotation of the poles of the field, and under these circumstances very little current is perceptible in the coils $E\ E'$; but if a load is added the speed tends to diminish and the currents in coils $E\ E'$ are augmented, so that the rotary effort is increased proportionately.

当这些电动机没有负载，只是自由运行，电枢的旋转几乎与磁场磁极的旋转同步，在这种情况下，线圈 $E\ E'$ 中的电流非常小；但是如果加上一个负载，速度会下降，线圈 $E\ E'$ 中的电流会增加，所以旋转力成比例地增加。

Obviously the principle of this invention is capable of many modified applications, most of which follow as a matter of course from the constructions described. For instance, the armature-coils, or those in which the currents are set up by induction, may be held stationary and the alternating currents from the generator conducted through the rotating inducing or field coils by means of suitable sliding contacts. It is also apparent that the induced coils may be movable and the magnetic parts of the motor stationary; but I have illustrated these modifications fully in the application to which reference has herein been made.

显然，本发明的原理能够有许多改进的应用，其中大部分当然是根据所描述的结构。例如，电枢线圈或利用感应产生电流的那些线圈可以保持静止，来自发电机的交流电利用合适的滑动触点被传导流经旋转中的施感线圈或励磁线圈。同样明显的是，感应线圈可以是可移动的，而电动机的磁性部分是静止的；但是我已经在本文参考的申请中充分说明了这些修改。

In the case of motors wound with independent field and armature circuits and operated by shifting their poles, as described in my said prior application, I may by short-circuiting the armature-coils apply the present invention in order to obtain greater power on starting.

在用独立的励磁电路和电枢电路来缠绕线圈并通过转移磁极来运行的电动机的例子中，如我在先前的申请中所描述的，我可以通过短路电枢线圈来应用本发明，以便在启动时获得更大

的功率。

An advantage and characteristic feature of motors constructed and operated in accordance with this invention is their capability of almost instantaneous reversal by a reversal of one of the energizing-currents from the generator. This will be understood from a consideration of the working conditions. Assuming the armature to be rotating in a certain direction following the movement of the shifting poles, then reverse the direction of the shifting, which may be done by reversing the connections of one of the two energizing-circuits. If it be borne in mind that in a dynamo-electric machine the energy developed is very nearly proportionate to the cube of the speed, it is evident that at such moment an extraordinary power is brought to play in reversing the motor. In addition to this the resistance of the motor is very greatly reduced at the moment of reversal, so that a much greater amount of current passes through the energizing-circuits.

根据本发明构建和运行的电动机的一个优点和特征是,它们能够通过来自发电机的励磁电流之一的一个反转而几乎瞬间反向。这将通过考虑工作条件来理解。假设电枢随着磁极的转移而在某个方向上即将旋转,那么反转转移的方向,就可以通过将这两个励磁电路之一的连接进行反转来完成。如果记住在电动发电机中,产生的能量与速度的立方几乎成正比,那么很明显,在这样的时刻,一种非凡的力量被用来反转电动机。除此之外,电动机的电阻在反转时会大大降低,因此会有更多的电流通过励磁电路。

The phenomenon alluded to—viz., the variation of the resistance of the motor apparently like that in ordinary motors—I attribute to the variation in the amount of self-induction in the primary or energizing circuits.

所暗示的现象——即电动机电阻的变化显然与普通电动机相似——我将其归因于初级电路或激励电路中自感应量的变化。

The motors present numerous advantages, chief among which are their simplicity, reliability, economy in construction and maintenance, and their easy and dangerless management. As no commutators are required on either the generators or the motors, the system is capable of a very perfect action and involves but little loss.

这种电动机有许多优点,其中最主要的是简单、可靠、建造和维护上的经济性,以及易于管理和没有危险。由于发电机和电动机都不需要换向器,所以该系统能够很好地工作,而且损耗很小。

I do not claim herein the mode or plan of producing currents in closed conductors in a magnetic field which is herein disclosed, except in its application to this particular purpose; but

我在此不主张在此公开的在磁场中的闭合导体中产生电流的模式或方案,除了它在这个特定目的中的应用;但

What I claim is—

我主张的是—

1. The combination, with a motor containing independent inducing or energizing circuits and closed induced circuits, of an alternating-current generator having induced or generating circuits corresponding to and connected with the energizing-circuits of the motor, as set forth.

1、一个交流发电机与包含了独立的施感电路或励磁电路和闭合的感应电路的一个电动机的组合,该交流发电机具有与该电动机的励磁电路相对应并相连接的感应电路或发电电路,如前所述。

2. An electro-magnetic motor having its field-magnets wound with independent coils and its armature with independent closed coils, in combination with a source of alternating currents connected to the field-coils and capable of progressively shifting the poles of the field-magnet, as set forth.

2、一种电磁电动机,其场磁体由独立线圈缠绕,并且其电枢由独立的闭合线圈缠绕,该电动机与连接到励磁线圈的交流电源相协作,并能够逐步转移场磁体的磁极,如上所述。

3. A motor constructed with an annular field-magnet wound with independent coils and a cylindrical or disk armature wound with closed coils, in combination with a source of alternating currents connected with the field-magnet coils and acting to progressively shift or rotate the poles of the field, as herein set forth.

3、一种电动机,由缠绕有独立线圈的环形场磁体和缠绕有闭合线圈的圆柱形或盘形电枢构成,并与场磁体线圈连接的交流电源相协作,用于逐步转移或旋转磁场的磁极,如本文所述。

NIKOLA TESLA.
尼古拉·特斯拉

Witnesses:

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(No Model.)

2 Sheets—Sheet 1.

N. TESLA.

ELECTRO MAGNETIC MOTOR.

No. 382,279.

Patented May 1, 1888.

Fig. 1.

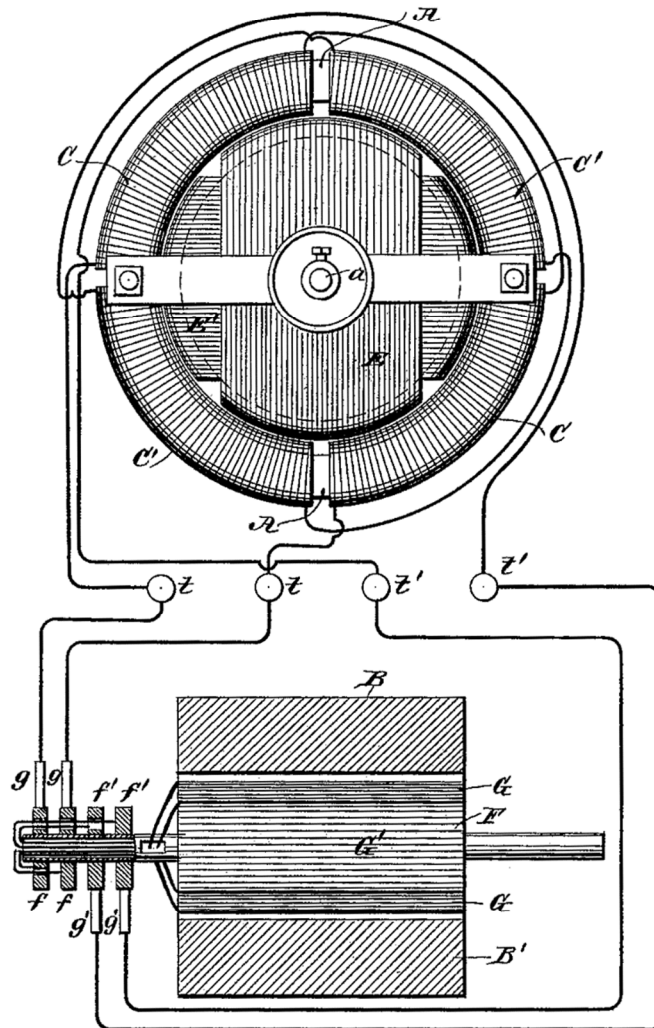
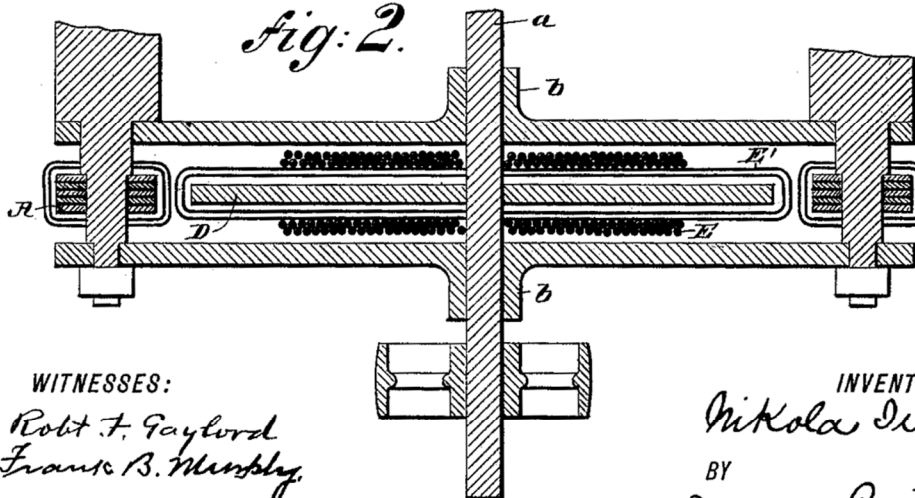


Fig. 2.



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ELECTRO MAGNETIC MOTOR.

No. 382,279.

Patented May 1, 1888.

Fig. 3.

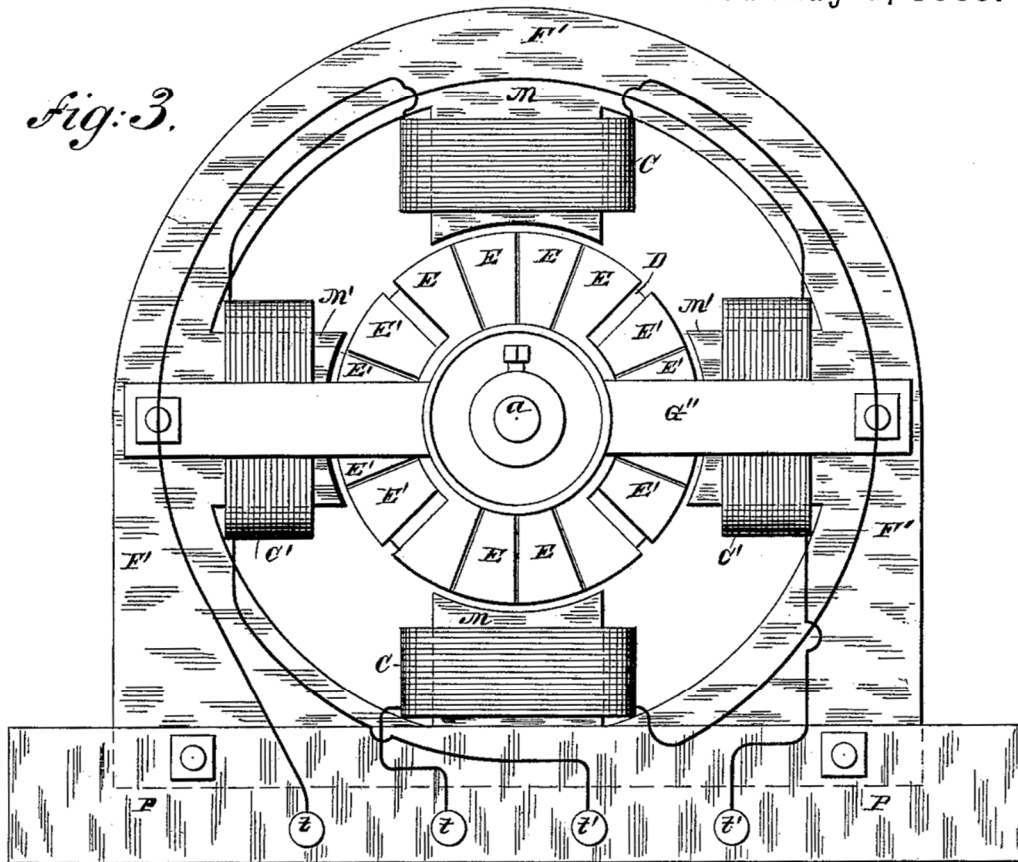
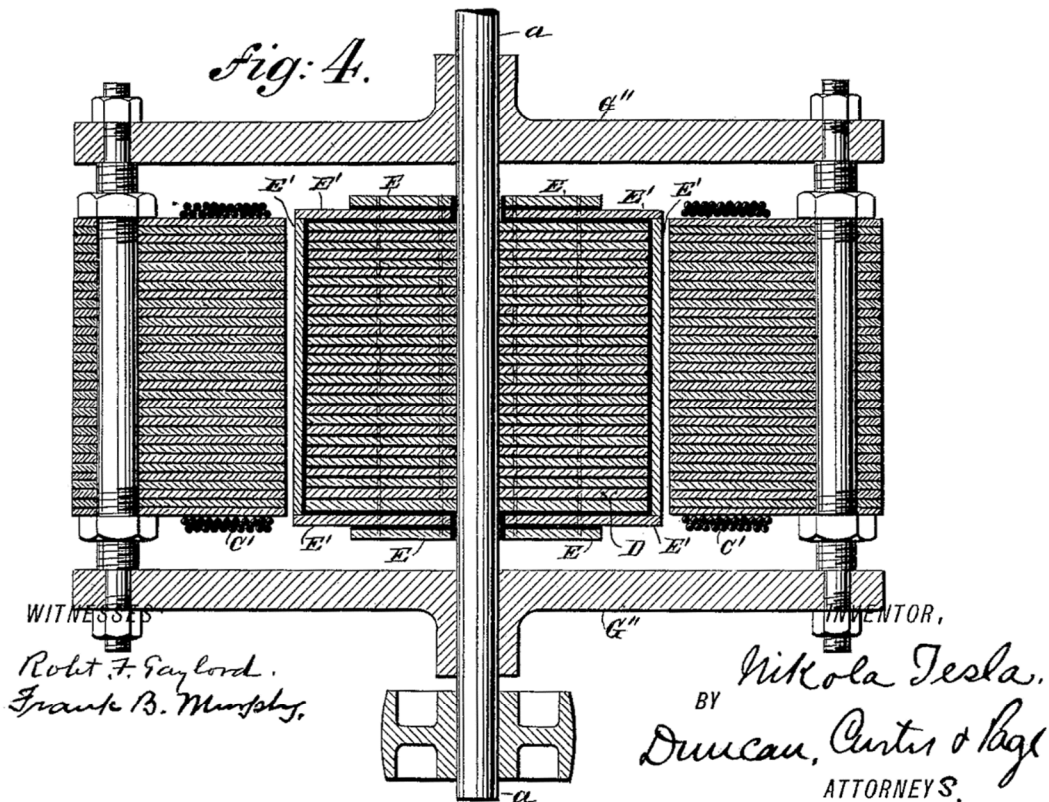


Fig. 4.



ELECTRICAL TRANSMISSION OF POWER.

电力传输

NIKOLA TESLA, OF NEW YORK, N.Y.

纽约州纽约市的尼古拉·特斯拉

SPECIFICATION forming part of Letters Patent No. 382,281, dated May 1, 1888.

Original application filed November 30, 1887. Serial No. 256,562. Divided and this application filed

March 9, 1888. Serial No. 266,756. (No model.)

该说明书形成了颁发于 1888 年 5 月 1 日编号为 382,281 的专利证书的一部分。

原申请于 1887 年 11 月 30 日提交。在 1888 年 3 月 9 日被分立并提交申请。

序列号为 256,562。(没有模型)

To all whom it may concern:

致所有相关人士：

Be it known that I, NIKOLA TESLA, from Smiljan, Lika, border country of Austria-Hungary, and residing in the city, county, and State of New York, have invented certain new and useful Improvements in the Electric Transmission of Power, of which the following is a specification, this application being a division of an application filed by me November 30, 1887, Serial No. 256,562.

众所周知，我、尼古拉·特斯拉，来自奥匈帝国边境地区的利卡县的史密里安村，居住在纽约州纽约郡纽约市，在电力传输方面已经发明了某些新的和有用的改进，以下是该发明一个说明书，该申请是在 1887 年 11 月 30 日由我提交的一个申请的分立，序列号 256,562。

In a previous application filed by me—viz., No. 252,132, filed October 12, 1887—I have set forth an improvement in motors and in the mode of operating the same, which, generally stated, consists in progressively and continuously shifting the poles or lines of maximum magnetic effect of either the field-magnets or armature, or both, of a motor, and thereby producing a movement of rotation in the motor. The means which I have shown for effecting this, while varying in detail, are exemplified in the following system, which, for present purposes, it will be sufficient to consider as a typical embodiment of the invention.

在我之前提交的一个申请中——即，在 1887 年 10 月 12 日提交的第 252,132 号申请中——我已经提出了一种对电动机及其运行模式的改进，一般来说，这种改进包括渐进地和持续地移动电动机的场磁体的或电枢的或两者的磁极或最大磁效应的磁力线，从而在电动机中产生旋转运动。我已经展示了用于实现这一点的措施，尽管在细节上有所不同，但这些措施要在下面的用于目前的目的系统被举例说明，该系统将足以被认为是本发明的典型实施例。

The motor is wound with coils forming independent energizing-circuits on the armature, which is a cylinder or disk mounted to rotate between two opposite magnetic poles. These coils are connected up with corresponding induced or current-producing circuits in an alternating current generator. As a result

of this, when the generator is set into motion, currents of alternately-opposite direction are directed through the energizing-coils of the motor in such manner as to produce a progressive shifting or rotation of the magnetic poles of the motor-armature. This movement of the poles of the armature obviously tends to rotate the armature in the opposite direction to that in which the movement of the poles takes place, owing to the attractive force between said poles and the field-magnets, and the speed of rotation increases from the start until it equals that of the generator, supposing both motor and generator to be alike.

电动机被缠绕有线圈，这些线圈在电枢上形成了独立的励磁电路，电枢是安装在两个相反磁极之间用来旋转的圆柱体或圆盘。这些线圈与一个交流发电机中相应的感应电路或电流产生电路相连。因此，当发电机开始运转时，交替相反方向的电流通过电动机的励磁线圈，从而产生电动机电枢磁极的一个渐进转移或旋转。由于所述磁极和场磁体之间的吸引力，电枢磁极的这种运动显然倾向于在与磁极运动发生的方向相反的方向上旋转电枢，并且假设电动机和发电机是相同的，旋转速度从开始增加直到它等于发电机的速度。

As the magnetic poles of the armature are shifted in a direction opposite to that in which the armature rotates, it will be apparent that when the normal speed is attained the poles of the armature will assume a fixed position relative to the field-magnets, and that in consequence the field-magnets will be energized by magnetic induction, exhibiting two distinct poles, one in each of the pole-pieces. In starting the motor, however, the speed of the armature being comparatively slow, the pole-pieces are subjected to rapid reversals of magnetic polarity; but as the speed increases these reversals become less and less frequent and finally cease, when the movement of the armature becomes synchronous with that of the generator. This being the case, the field-cores or the pole-pieces of the motor become a magnet, but by induction only.

当电枢的磁极在与电枢旋转方向相反的方向上旋转时，很明显，当达到正常速度时，电枢的磁极将相对于场磁体呈现出固定位置，因此场磁体将通过磁感应被励磁，呈现两个不同的磁极，每个极靴中有一个。然而，在启动电动机时，电枢的速度相对较慢，极靴会经历磁极的快速反转；但是随着速度的增加，这种反转变得越来越不频繁，最后当电枢的运动与发电机的运动同步时，这种反转就停止了。在这种情况下，电动机的励磁铁芯和极靴仅仅是通过感应就变成了一个磁体。

I have found that advantageous results are secured by winding the field-magnets with a coil or coils and passing a continuous current through them, thus maintaining a permanent field, and in this feature my present invention consists.

我已经发现，通过用一个或多个线圈缠绕场磁体并使恒向电流通过它们，从而维持一个持久磁场，可以获得有利的结果，并且我的发明也包括这个特征。

I shall now describe the apparatus which I have devised for carrying out this invention and explain the mode of using or operating the same.

我现在将描述我为实施本发明而设计的装置，并解释使用或运行该装置的方式。

Figure 1 is an end view in elevation of my improved motor. Fig. 2 is a part horizontal central section,

and Fig. 3 is a diagrammatic representation of the motor and generator combined and connected for operation.

图 1 是我的改进后的电动机的端视图。图 2 是一个部件的水平中心截面图，图 3 是电动机和发电机的组合和用于运行的连接的示意图。

Let A A in Fig . 1 represent the legs or pole-pieces of a field-magnet, around which are coils B B, included in the circuit of a continuous-current generator, C, which is adapted to impart magnetism to the said poles in the ordinary manner.

图 1 中的 A A 表示场磁体的腿或极靴，其周围是线圈 B B，该线圈被包含在一个恒向电流发生器 C 的电路中，该电路适于以普通方式将磁性赋予所述磁极。

D D' are two independent coils wound upon a suitable cylindrical or equivalent armature-core, which, like all others used in a similar manner, should be split or divided up into alternate magnetic and insulating parts in the usual way. This armature is mounted in non-magnetic cross-bars E E, secured to the poles of the field-magnet. The terminals of the armature-coils D D' are connected to insulated sliding contact-rings a a b b, carried by the armature-shaft, and brushes c c bear upon these rings to convey to the coils the currents which operate the motor.

D D'是缠绕在一个合适的圆柱形或等效电枢铁芯上的两个独立线圈，与所有其他以类似方式使用的线圈一样，应以通常方式分割或切割成交替的磁性和绝缘部分。这个电枢被安装在非磁性交叉杆 E E 上，该交叉杆被固定在场磁铁的磁极上。电枢线圈 D D'的终端连接到由电枢轴支撑的被绝缘的滑动接触环 a a b b 上，电刷 c c'压在这些环上，将驱动电动机的电流传送到线圈。

The generator for operating this motor is or may be of precisely identical construction, and for convenience of reference I have marked in Fig. 3 its parts, as follows: F F, the field-magnets energized by a continuous current passing in its field-coils G G, H H', the coils carried by the cylindrical armature; d d e e, the friction or collecting rings carried by the armature-shaft and forming the terminals of the armature-coils; and f f the collecting-brushes which deliver the currents developed in the armature-coils to the two circuits g g', which connect the generator with the motor.

用于运行该电动机的发电机是或者可以是完全一致的结构；为了便于参考，我在图 3 中标记了它的部件，如下：F F，场磁铁，由通过它的励磁线圈 G G 的恒向电流所激励；H H'，由圆柱形电枢携带的线圈；d d e e，摩擦环或集电环，由电枢轴承载，形成电枢线圈的终端；以及 f f'，集电刷，将电枢线圈中产生的电流传送到连接发电机和电动机的两个电路 g g'。

The operation of this system will be understood from the foregoing. The action of the generator by causing a progressive shifting of the poles in the motor-armature sets up in the latter a rotation opposite in direction to that in which the poles move. If, now, the continuous current be directed through the field-coils so as to strongly energize the magnet A A, the speed of the motor, which depends upon that of the generator, will not be increased, but the power which produces its rotation will be increased in proportion to the energy supplied through the coils B B. It is characteristic of this motor that its direction of rotation is not reversed by reversing the direction of the current through its field-coils, for

the direction of rotation depends not upon the polarity of the field, but upon the direction in which the poles of the armature are shifted. To reverse the motor the connections of either of the circuits $g g'$ must be reversed.

从前面的描述中可以理解该系统的操作。发电机的作用是使电动机电枢中的磁极逐渐转移，从而使电枢产生与磁极移动方向相反的旋转。现在，如果恒向电流通过磁场线圈，来强烈地激励磁体 $A A$ ，取决于发电机的速度的电动机的速度不会增加，但产生电动机旋转的功率将与线圈 $B B$ 提供的能量成正比例地增加。这种电动机的特点是，它的旋转方向不会因通过励磁线圈的电流方向的反转而反转，因为旋转方向不取决于磁场的极性，而是取决于电枢磁极移动的方向。要反转电动机，必须反转电路 $g g'$ 的任一连接。

I have found that if the field-magnet of the motor be strongly energized by its coils $B B$, and the circuits through the armature-coils closed, assuming the generator to be running at a certain speed, the motor will not start; but if the field be but slightly energized, or in general in such condition that the magnetic influence of the armature preponderates in determining its magnetic condition, the motor will start, and with sufficient current will reach its maximum or normal speed. For this reason it is desirable to keep at the start, and until the motor has attained its normal speed, or nearly so, the field-circuit open, or to permit but little current to pass through it. I have found, however, if the fields of both the generator and motor be strongly energized that starting the generator starts the motor, and that the speed of the motor is increased in synchronism with the generator.

我已发现，如果电动机的场磁体被其线圈 $B B$ 强烈励磁，并且通过电枢线圈的电路闭合，假设发电机以一定的速度运行，电动机将不会启动；但是，如果磁场只是轻微励磁，或者一般情况下，电枢的磁性影响在确定其磁性条件时占优势，电动机将启动，并在足够的电流下，将达到其最大或正常速度。由于这个原因，最好是在启动时保持励磁电路开路或者只允许很小的电流通过，直到电动机达到正常速度或接近正常速度。然而，我发现，如果发电机和电动机的磁场都被强烈激励，那么启动发电机就启动了电动机，并且电动机的速度与发电机同步增加。

Motors constructed and operated on this principle maintain almost absolutely the same speed for all loads within their normal working-limits, and in practice I have observed that if the motor be overloaded to such an extent as to check its speed the speed of the generator, if its motive power be not too great, is diminished synchronously with that of the motor.

根据这一原理制造和运行的电动机，在其正常工作限度内，对所有负载都保持几乎绝对相同的速度；并且在实践中，我观察到，如果电动机过载到抑制其速度的程度，则发电机的速度（如果其动力不太大）将与电动机的速度同步减小。

I have in other applications shown how the construction of these or similar motors may be varied in certain well-known ways—as, for instance, by rotating the field about a stationary armature or rotating conductors within the field—but I do not illustrate these features further herein, as with the illustration which I have given I regard the rest as within the power of a person skilled in the art to construct.

我在其他应用中展示了这些或类似的电动机的结构如何以某些众所周知的方式变化——例如，例如，通过围绕着一个固定电枢旋转磁场，或旋转磁场内的导体；但是我在此不进一步

说明这些特征，因为对于我已经给出的说明，我认为其余部分在本领域技术人员的能力范围内。

I am aware that a device embodying the characteristics of a motor and having a permanently-magnetized field-magnet has been operated by passing through independent coils on its armature a direct or continuous current in opposite directions. Such a system, however, I do not regard as capable of the practical applications for which my invention is designed, nor is it the same in principle or mode of operation, mainly in that the shifting of the poles is intermittent and not continuous, and that there is necessarily involved a waste of energy.

我意识到体现了电动机的特性和具有一个永久磁化的磁场的一个装置，是利用以相反方向穿过电枢上的不同独立线圈的直流电流或恒向电流来运行的。然而，这样的系统，我不认为能够实现我的发明所设计的实际应用，它在原理或操作模式上也不相同，主要在于磁极的转移是间歇的而不是连续的，并且必然涉及能量的浪费。

In my present application I do not limit myself to any special form of motor, nor of the means for producing the alternating currents as distinguished from what are called “reversed currents,” and I may excite or energize the field of the motor and of the generator by any source of current which will produce the desired result.

在我目前的申请中，我并不局限于任何特定形式的电机，也不局限于用于产生区别于所谓的“反向电流”的交流电的装置，并且我可以利用将产生期望结果的任何电流源来激励或激发电动机和发电机的磁场。

What I claim is—

我主张的是—

The method herein described of transmitting power by electro-magnetic motors, which consists in continuously and progressively shifting the poles of one element of the motor by alternating currents and magnetizing the other element by a direct or continuous current, as set forth.

这里描述的利用电磁电动机传输电力的方法，包括通过交流电流持续地和渐进地转移电动机的一个组件的多个磁极，并通过一个直流电流或恒向电流磁化另一个组件，如前所述。

NIKOLA TESLA.

尼古拉·特斯拉

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(No Model.)

2 Sheets—Sheet 1.

N. TESLA.

ELECTRICAL TRANSMISSION OF POWER.

No. 382,281.

Patented May 1, 1888.

Fig. 1

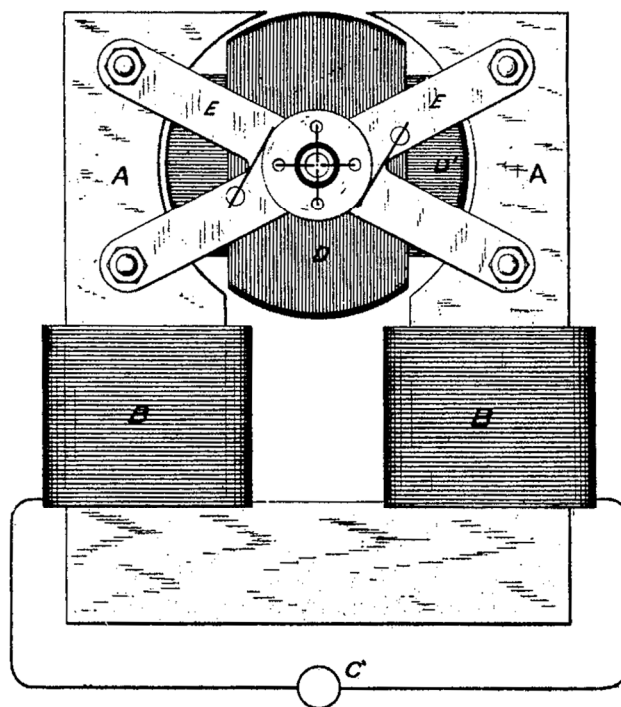
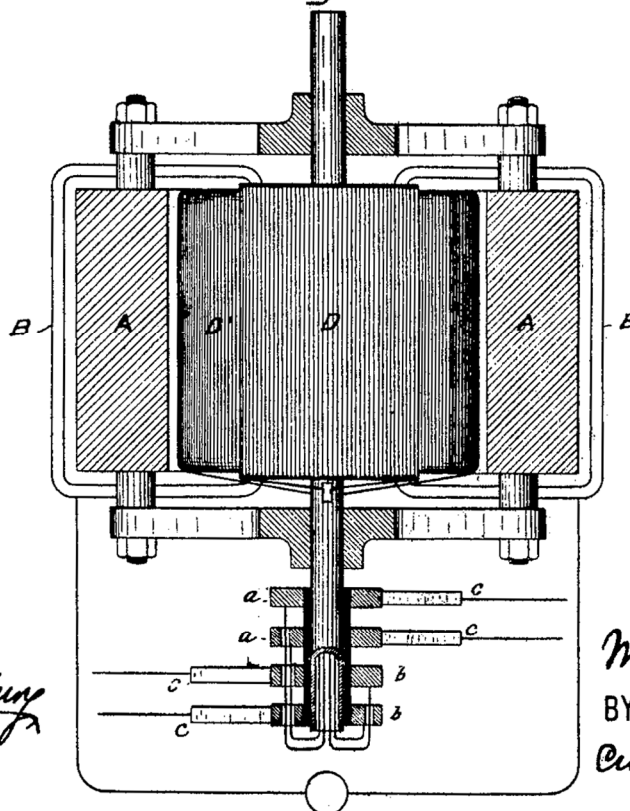


Fig. 2



WITNESSES:

Raphael Miller.
Henry J. Newburg

INVENTOR.

Nikola Tesla.
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Curtis & Page.
ATTORNEYS.

(No Model.)

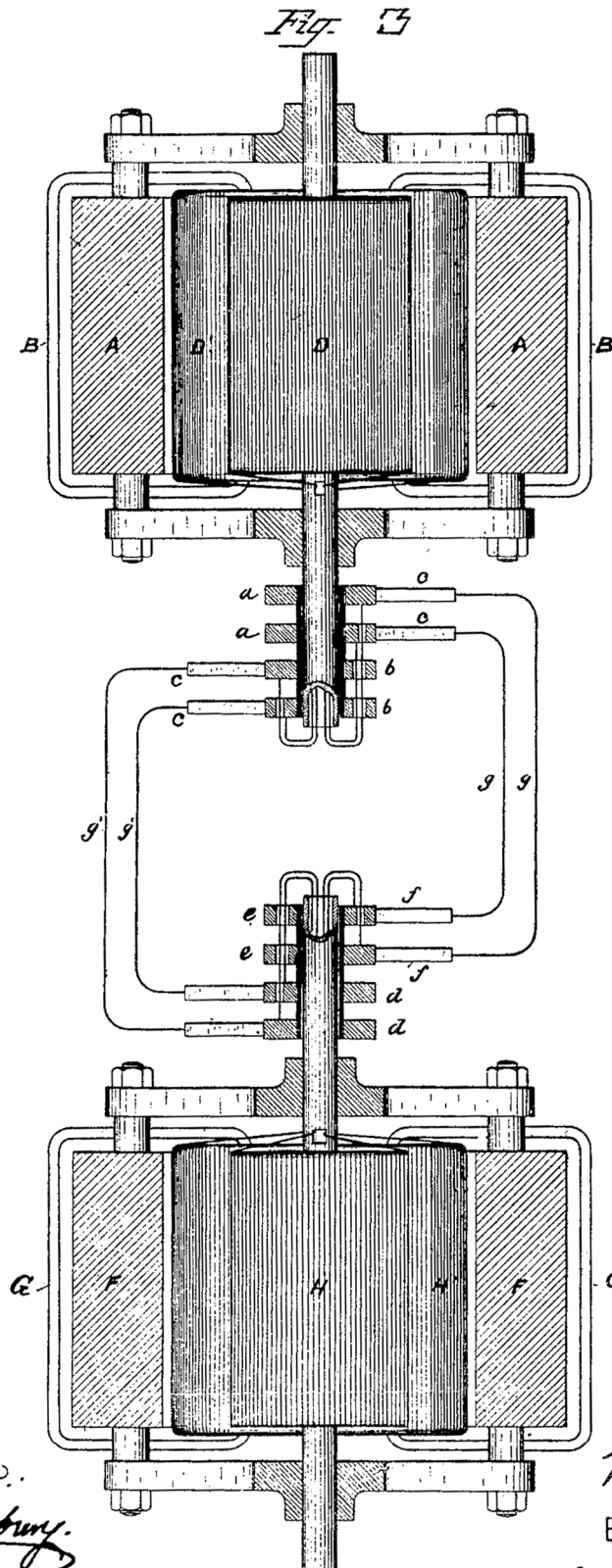
2 Sheets—Sheet 2.

N. TESLA.

ELECTRICAL TRANSMISSION OF POWER.

No. 382,281.

Patented May 1, 1888.



WITNESSES:

Raphael Netter.
Henry F. Newton.

INVENTOR.

Nikola Tesla

BY *Duncan,*
Curtis & Page.
ATTORNEYS

METHOD OF CONVERTING AND DISTRIBUTING ELECTRIC CURRENTS.

转换和分配电流的方法

NIKOLA TESLA, OF NEW YORK, N.Y.

纽约州纽约市的尼古拉·特斯拉

SPECIFICATION forming part of Letters Patent No. 382,282, dated May 1, 1888.

Original application filed December 23, 1887, Serial No. 258,787. Divided and this application filed
March 9, 1888. Serial No. 266,757. (No model.)

该说明书形成了颁发于 1888 年 5 月 1 日编号为 382,282 的专利证书的一部分。
申请于 1887 年 12 月 23 日提交。在 1888 年 3 月 9 日该申请被分立并被提交，序列号为
266,757。(没有模型)

To all whom it may concern:

致所有相关人士:

Be it known that I, NIKOLA TESLA, from Smiljan, Lika, border country of Austria-Hungary, and now residing at New York, in the county and State of New York, have invented certain new and useful Improvements in Methods of Converting and Distributing Electric Currents, of which the following is a specification, this application being a division of an application filed by me December 23, 1887, Serial No. 258,787.

众所周知，我、尼古拉·特斯拉、一位奥匈帝国的臣民，来自奥匈帝国边境地区的利卡县的史密里安村，现在居住在纽约州纽约郡纽约市，在转换和分配电流的方法方面已经发明了某些新的和有用的改进，以下是该发明一个说明书，该申请是我在 1887 年 12 月 23 日提交的序列号为 258,787 的申请的一个分立。

The invention relates to those systems of electrical distribution in which a current from a single source of supply in a main or transmitting circuit is caused to induce, by means of suitable induction apparatus, a current or currents in an independent working circuit or circuits.

本发明涉及这样的配电系统，在这样的系统中，利用合适的感应装置使来自主电路或输电电路中的单个电源的电流在独立的工作电路中感应出一个或多个电流。

The main objects of the invention are the same as have been heretofore obtained by use of these systems—viz., to divide the current from a single source, whereby a number of lamps, motors, or other translating devices may be independently controlled and operated by the same source of current, and in some cases to reduce a current of high potential in the main circuit to one of greater quantity and lower potential in the independent consumption or working circuit or circuits.

本发明的主要目的与迄今为止通过使用这些系统获得的目的相同——即分配来自单个电源的电流，由此多个电灯、电动机或其他转换装置可以由同一个电流源独立控制和运行，并且在一些情况下，可以将主电路中的一个高电位电流减小到在独立的消耗电路或工作电路中的较大量和较低电位这二者中的一种。

The general character of the devices employed in these systems is now well understood. An alternating-current magneto-machine is used as the source of supply. The current developed thereby is conducted through a transmission-circuit to one or more distant points, at which the transformers are located. These consist of induction-machines of various kinds. In some cases ordinary forms of induction-coils have been used with one coil in the transmitting-circuit and the other in a local or consumption circuit, the coils being differently proportioned, according to the work to be done in the consumption-circuit—that is to say, if the work requires a current of higher potential than that in the transmission-circuit the secondary or induced coil is of greater length and resistance than the primary, while on the other hand, if a quantity current of lower potential is wanted, the longer coil is made the primary. In lieu of these devices various forms of electro-dynamic induction-machines, including the combined motors and generators, have been devised. For instance, a motor is constructed in accordance with well-understood principles, and on the same armature are wound induced coils which constitute a generator. The motor-coils are generally of fine wire and the generator-coils of coarser wire, so as to produce a current of greater quantity and lower potential than the line-current, which is of relatively high potential, to avoid loss in long transmission. A similar arrangement is to wind coils corresponding to those described on a ring or similar core, and by means of a commutator of suitable kind to direct the current through the inducing-coils successively, so as to maintain a movement of the poles of the core or of the lines of force which set up the currents in the induced coils.

这些系统中使用的设备的一般特性现在已经很好理解了。一个交流磁电机被用作一个电源。由此产生的电流通过一个传输电路被传导到变压器所在的一个或多个远点。这些包括各种各样的感应机器。在某些情况下，使用普通形式的感应线圈，一个线圈在传输电路中，另一个线圈在本地或消耗电路中，这些线圈根据消耗电路中要做的工作而成不同的比例，也就是说，如果工作需要比传输电路中的电流更高电势的电流，则次级或感应线圈比初级线圈具有更大的长度和电阻，而另一方面，如果需要较低电势的电流量，则较长的线圈被制成初级线圈。已经设计出各种形式的电动感应电机来代替这些装置，包括组合式电动机和发电机。例如，一个电动机是根据众所周知的原理构建的，在同一个电枢上缠绕着构成发电机的感应线圈。电动机线圈通常由细导线制成，而发电机线圈由粗导线制成，以便产生比线路电流更大电流量和更低电势的电流，线路电流具有相对较高的电势，以避免长距离传输中的损耗。一个类似的布置是缠绕对应于在一个环形铁芯或类似的铁芯中的描述过的那些线圈，并且借助于合适种类的一个换向器来引导电流相继通过感应线圈，以便保持铁芯的磁极的一个运动和在感应线圈中建立电流的磁力线的一个运动。

Without enumerating the objections to these systems in detail, it will suffice to say that the theory or the principle of the action or operation of these devices has apparently been so little understood that their proper construction and use have up to the present time been attended with various difficulties and great expense. The transformers are very liable to be injured and burned out, and the means resorted to for curing this and other defects have almost invariably been at the expense of efficiency. I have discovered a method of conversion and distribution, however, which is not subject to the defects and objections to which I have alluded, and which is both efficient and safe. I secure by it a conversion by

true dynamic induction under highly efficient condition and without the use of expensive or complicated apparatus or moving devices, which in use wear out and require attention. This method consists in progressively and continuously shifting the line or points of maximum effect in an inductive field across the convolutions of a coil or conductor within the influence of said field and included in or forming part of a secondary or translating circuit.

没有详细列举对这些系统的缺点,可以说这些装置的作用或运行的理论或原理显然很少被理解,以至于它们的正确的构建和使用遇到了各种困难和花费了巨大的费用。变压器很容易被损坏和烧毁,为解决这一缺陷和其他缺陷而采取的措施几乎总是以牺牲效率为代价。然而,我已经发现了一种转换和分配的方法,该方法不受我已经提到的缺陷的影响,并且既有效又安全。我利用在高效的条件下的真正的动态感应通过该方法得到了一种转换,而不使用昂贵或复杂的装置或移动设备,这些在使用中会磨损并需要注意。该方法在于逐渐地和连续地转移在感应场内最大效应的力线或点,来穿过一个线圈或者导体的匝圈,这些匝圈在所述场的影响范围内并被包含在一个次级电路或一个转换电路中或者形成了这些电路的一部分。

In carrying out my invention I provide a series of inducing-coils and corresponding induced coils which, by preference, I wind upon a core closed upon itself—such as an annulus or ring—subdivided in the usual manner. The two sets of coils are wound side by side or superposed or otherwise placed in well-known ways to bring them into the most effective relations to one another and to the core. The inducing or primary coils wound on the core are divided into pairs or sets by the proper electrical connections, so that while the coils of one pair or set to co-operate in fixing the magnetic poles of the core at two given diametrically-opposite points the coils of the other pair or set—assuming, for sake of illustration, that there are but two—tend to fix the poles ninety degrees from such points. With this induction device I use an alternating-current generator with coils or sets of coils to correspond with those of the converter, and by means of suitable conductors I connect up in independent circuits the corresponding coils of the generator and converter. It results from this that the different electrical phases in the generator are attended by corresponding magnetic changes in the converter; or, in other words, that as the generator-coils revolve the points of greatest magnetic intensity in the converter will be progressively shifted or whirled around. This principle I have applied under variously modified conditions to the operation of electro-magnetic motors, and in previous applications—notably in those having serial numbers 252,132 and 256,561—I have described in detail the manner of constructing and using such motors.

在实施我的发明时,我提供了一系列施感线圈和相应的感应线圈,首选地,我将线圈缠绕在一个自身闭合的铁芯上——例如以通常方式细分的环或圈。这两组线圈并排缠绕或重叠,或者以众所周知的方式放置,以使得它们彼此之间以及与铁芯之间形成最有效的关系。缠绕在铁芯上的施感线圈或初级线圈通过适当的电连接分成线圈对或线圈组,从而当一个线圈对或一个线圈组合作将铁芯的磁极固定在两个给定的径向相对的点上时,另一个线圈对或线圈组——为了便于说明,假设只有两对——倾向于将磁极固定在与这些点成 90 度的位置上。对于这种感应装置,我使用带有线圈或线圈组的交流发电机与转换器的线圈或线圈组相对应,并通过合适的导体将发电机和转换器的相应线圈连接在独立的电路中。由此导致发电机中不同的电相位伴随着转换器中相应的磁变化;或者,换句话说,随着发电机线圈旋转,转换器中最大磁场强度的点将逐渐转移或旋转。我已经在各种修改的条件下将该原理应用于电磁电动机的运行,并且在以前的申请中,特别是在序列号为 252,132 和 256,561 的申请中,我已经详细描述了构建和使用这种电动机的方式。

In the present application my object is to describe the best and most convenient manner of which I am at present aware of carrying out the invention as applied to a system of electrical distribution; but one skilled in the art will readily understand, from the description of the modifications proposed in said applications, wherein the form of both the generator and converter in the present case may be modified. In illustration, therefore, of the details of construction which my present invention involves, I now refer to the accompanying drawings.

在本申请中,我的目的是描述我目前所知的实施本发明应用于配电系统的最佳和最方便的方式;但是本领域的技术人员将通过在所述申请中提出的修改从描述中容易地理解,其中在当前情况下发电机和转换器的形式都可以被修改。因此,为了说明本发明所涉及的结构细节,我现在参照附图。

Figure 1 is a diagrammatic illustration of the converter and the electrical connections of the same. Fig. 2 is a horizontal central cross-section of Fig. 1. Fig 3 is a diagram of the circuits of the entire system, the generator being shown in section.

图 1 是转换器及其电气连接的示意图。图 2 是图 1 的水平中心截面图。图 3 是整个系统的电路图,发电机以截面展示。

I use a core, A, which is closed upon itself—that is to say, of an annular, cylindrical, or equivalent form—and as the efficiency of the apparatus is largely increased by the subdivision of this core I make it of thin strips, plates, or wires of soft iron electrically insulated as far as practicable. Upon this core, by any well-known method, I wind, say, four coils, B B B' B', which I use as primary coils, and for which I use long length of comparatively fine wire, Over these coils I then wind shorter coils of coarser wire, C C C' C', to constitute the induced or secondary coils. The construction of this or any equivalent form of converter may be carried farther, as above pointed out, by inclosing these coils with iron—as, for example, by winding over the coils a layer or layers of insulated iron wire.

我使用一个铁芯 A,它本身是闭合的——也就是说,一个环形的圆柱或等效的形式——并且由于该铁芯的细分大大提高了设备的效率,因此我将其尽可能地用电绝缘的软铁薄条、板或线来制成铁芯 A。我通过任何众所周知的方法在这个铁芯上缠绕了四个线圈,比如说, B B B' B', 我将它们用作初级线圈,并且使用了大长度的相对较细的导线。在这些线圈上,我用较粗的导线绕制了较短的线圈 C C C' C',以构成感应线圈或次级线圈。如上所述,通过用铁包围这些线圈,例如通过在线圈上缠绕一层或多层被绝缘的铁丝,可以进一步实现转换器的这种构造或任何等效形式。

The device is provided with suitable binding-posts, to which the ends of the coils are led. The diametrically-opposite coils B B and B' B' are connected, respectively, in series, and the four terminals are connected to the binding-posts 1 2 3 4. The induced coils are connected together in any desired manner. For example, as shown in Fig. 3, C C may be connected in multiple arc when a quantity current is desired—as for running a group of incandescent lamps, D—while C' C' may be independently connected in series in a circuit including arc lamps D' or the like.

该装置配有合适的接线柱,线圈的端部被引导到该接线柱。径向相对的线圈 B B 串联连接,径向相对的线圈 B' B' 串联连接,并且四个端子连接到接线柱 1 2 3 4。感应线圈以任何期望的

方式连接在一起。例如，如图 3 所示，当需要一定量的电流时，C C 可以以多弧方式连接，如运行一组白炽灯，D——而 C' C'可以独立地串联在包含弧光灯 D'等的电路中。

The generator in this system will be adapted to the converter in the manner illustrated. For example, in the present case I employ a pair of ordinary permanent or electromagnets, E E, between which is mounted a cylindrical armature on a shaft, F, and wound with two coils, G G'. The terminals of these coils are connected, respectively, to four insulated contact or collecting-rings, H H H' H', and the four line-circuit wires L connect the brushes K bearing on these rings to the converter in the order shown. Noting the results of this combination, it will be observed that at a given point of time the coil G is in its neutral position and is generating little or no current, while the other coil, G', is in a position where it exerts its maximum effect. Assuming coil G to be connected in circuit with coils B B of the converter, and coil G' with coils B' B', it is evident that the poles of the ring A will be determined by coils B' B' alone; but as the armature of the generator revolves, coil G develops more current and coil G' less until G reaches its maximum and G' its neutral position. The obvious result will be to shift the poles of the ring A through one quarter of its periphery. The movement of the coils through the next quarter of a turn, during which coil G' enters a field of opposite polarity and generates a current of opposite direction and increasing strength, while coil G is passing from its maximum to its neutral position, generates a current of decreasing strength and same direction as before, and causes a further shifting of the poles through the second quarter of the ring. The second half-revolution will obviously be a repetition of the same action. By the shifting of the poles of the ring A a power-dynamic inductive effect on the coils C C' is produced. Besides the currents generated in the secondary coils by dynamo-magnetic induction, other currents will be set up in the same coils in consequence of any variations in the intensity of the poles in the ring A. This should be avoided by maintaining the intensity of the poles constant, to accomplish which care should be taken in designing and proportioning the generator and in distributing the coils in the ring A and balancing their effect. When this is done, the currents are produced by dynamo-magnetic induction only, the same result being obtained as though the poles were shifted by a commutator with an infinite number of segments.

该装置配有合适的接线柱，线圈的端部被引导到该接线柱。径向相对的线圈 B B 串联连接，径向相对的线圈 B' B' 串联连接，并且四个端子连接到接线柱 1 2 3 4。感应线圈以任何期望的方式连接在一起。例如，如图 3 所示，当需要一定量的电流时，C C 可以以多弧方式连接，如运行一组白炽灯，D——而 C' C'可以独立地串联在包含弧光灯等负载的电路中。该系统中的发电机将以图示的方式适合于转换器。例如，在目前的情况下，我使用一对普通的永磁体或电磁体 E E，在它们之间在一个轴 F 上安装一个圆柱形电枢，并缠绕上两个线圈 G G'。这些线圈的终端分别连接到四个被绝缘的接触环或集电环 H H H' H' 上，并且四条线路的电路导线 L 把倚靠在这些环上的电刷 K 按所示顺序连接到转换器上。注意这种组合的结果，将会观察到，在给定的时间点，线圈 G 处于其中性位置并且产生很少电流或没有电流，而另一个线圈 G' 处于发挥其最大效果的位置。假设线圈 G 在电路中与转换器的线圈 B B 连接，并且线圈 G' 与线圈 B' B' 连接，显然，环 A 的极点将仅由线圈 B' B' 确定；但是当发电机的电枢旋转时，线圈 G 产生更多的电流，而线圈 G' 产生更少的电流，直到 G 达到最大值，并且 G' 处于中性位置。明显的结果是环 A 的极点将移动经过其外围的四分之一。线圈通过下一个四分之一圈的运动，在此期间，线圈 G' 进入相反极性的磁场，并产生相反方向的且强度增强的电流，而线圈 G 在从其最大值到其中性位置的过程中，产生强度减小且方向与之前相同的电流，这导致磁极进一步转移并通过环的第二个四分之一圈。第二次半圈显然是同一动作的重复。通过环 A 磁极的转移，在线圈 C C' 上产生一个强大的动态感应效应。除了由电动

机的发电机-磁感应在次级线圈中产生的电流之外，由于环 A 中磁极强度的任何变化，在上述线圈中将产生其它电流。应通过保持磁极强度不变来避免这种情况，为此，在设计和均衡发电机以及在环 A 中分配线圈和平衡它们的效果时应小心谨慎。当这样做时，电流仅由发电机-磁感应产生，获得的结果相同，所获得的结果就好像这些磁极被一个具有无限数量分段的换向器转移了一样。

The apparatus by means of which this method of conversion is or may be carried out may be varied almost indefinitely. The specific form which I have herein shown I regard as the best and most efficient, and in another application I have claimed it; but I do not limit myself herein to the use of any particular form or combination of devices which is or may be capable of effecting the same result in a similar way.

实现或可能实现这种转化方法的装置几乎可以无限地变化。我认为我在此展示的特定形式是最好和最有效的，并且在另一个应用中我已经提出了主张；但是我在此并不将自己限制于使用任何特定形式或组合的装置，这些装置能够或可能能够以类似的方式实现相同的结果。

What I claim is—

我主张的是—

1. The method of electrical conversion and distribution herein described, which consists in continuously and progressively shifting the points or line of maximum effect in an inductive field, and inducing thereby currents in the coils or convolutions of a circuit located within the inductive influence of said field, as herein set forth.

1、本文描述的转换和分配电力的方法，在于连续地和渐进地转移感应场中最大效应的点或力线，从而在位于所述场的感应影响内的电路的线圈或匝中感应出电流，如本文所述。

2. The method of electrical conversion and distribution herein described, which consists in generating independent circuits producing an inductive field alternating currents in such order or manner as to produce by their conjoint effect a progressive shifting of the points of maximum effect of the field, and inducing thereby currents in the coils or convolutions of a circuit located within the inductive influence of the field, as set forth.

2、这里描述的电转换和分配的方法在于在独立的电路中以这样的顺序或方式产生一个感应场，使得通过这些场的联合效应实现场的最大效应点的渐进移动，从而在位于场的感应影响内的电路的线圈或匝圈中感应出电流，如上所述。

NIKOLA TESLA.

尼古拉·特斯拉

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(No Model.)

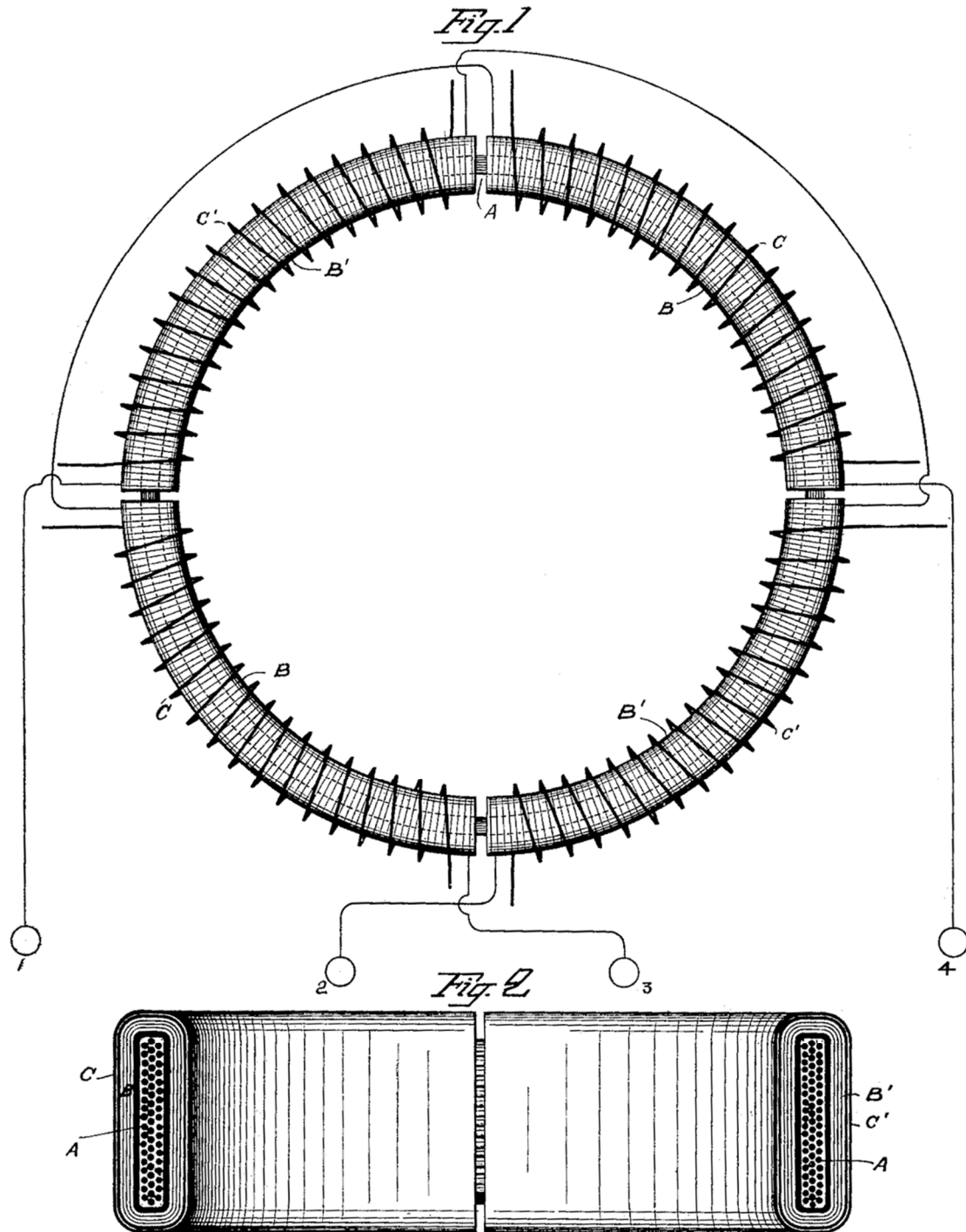
2 Sheets—Sheet 1.

N. TESLA.

METHOD OF CONVERTING AND DISTRIBUTING ELECTRIC CURRENTS.

No. 382,282.

Patented May 1, 1888.



WITNESSES:

Raphael Netter
Frank B. Murphy.

INVENTOR,

Nikola Tesla.

BY

BY
Duncan, Curtis & Page
ATTORNEYS.

(No Model.)

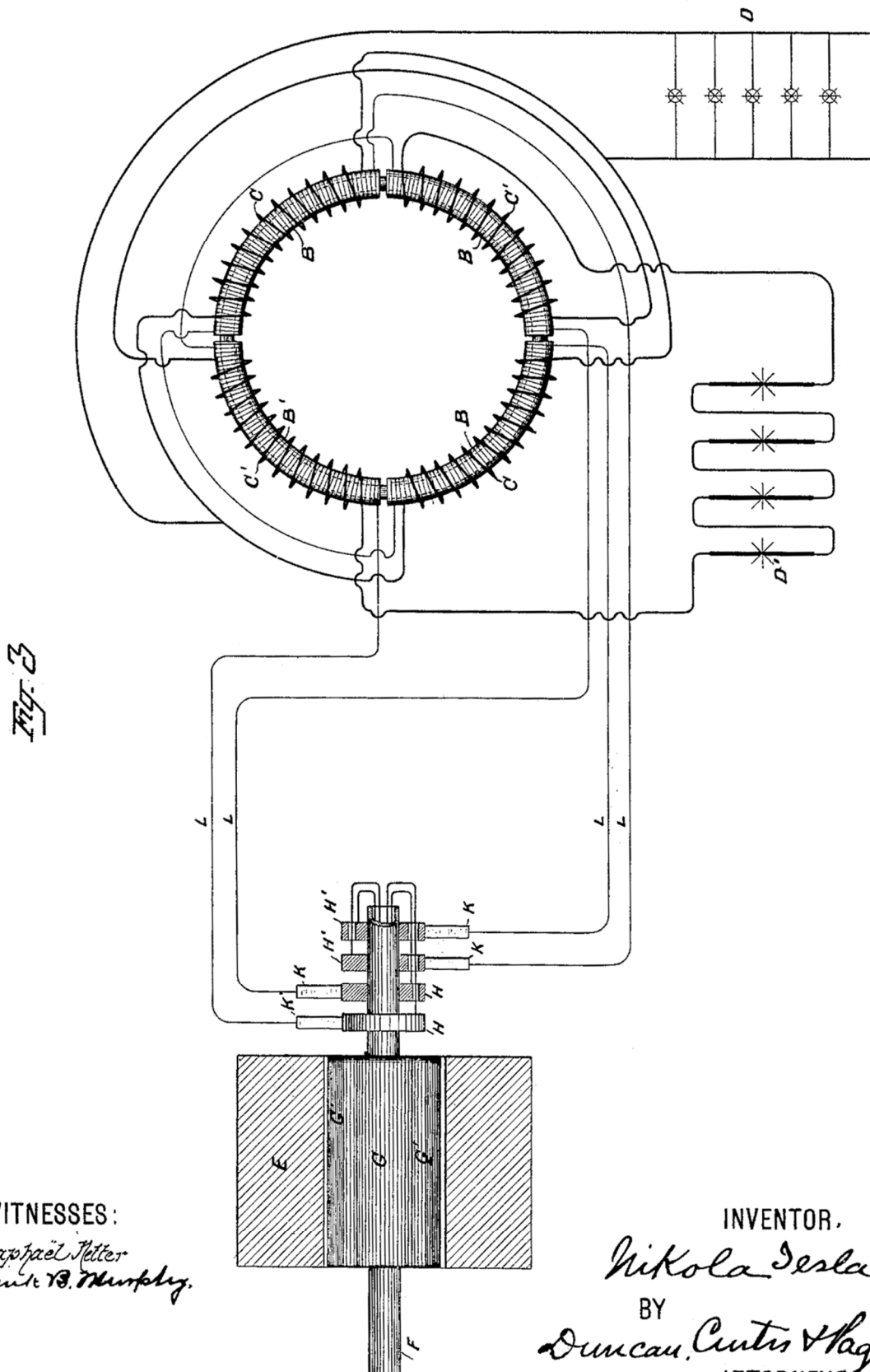
2 Sheets—Sheet 2.

N. TESLA.

METHOD OF CONVERTING AND DISTRIBUTING ELECTRIC CURRENTS.

No. 382,282.

Patented May 1, 1888.



COMMUTATOR FOR DYNAMO- ELECTRIC MACHINES.

用于电动发电机的换向器

NIKOLA TESLA, OF NEW YORK, N.Y., ASSIGNOR OF ONE-HALF TO CHARLES F.
PECK, OF ENGLEWOOD, NEW JERSEY.

纽约州纽约市的尼古拉·特斯拉，将一半专利权转让给
新泽西州恩格尔伍德市的查尔斯·F·佩克。

SPECIFICATION forming part of Letters Patent No. 382,845, dated May 15, 1888.

Application filed April 30, 1887. Serial No. 236,711. (No model.)

该说明书形成了颁发于 1888 年 5 月 15 日编号为 382,845 的专利证书的一部分。

申请于 1887 年 4 月 30 日提交。序列号为 236,711。(没有模型)

To all whom it may concern:

致所有相关人士:

Be it known that I, NIKOLA TESLA, from Smiljan, Lika, border country of Austria-Hungary, at present residing in this city, county, and State of New York, have invented certain new and useful Improvement in Commutators for Dynamo-Electric Machines and Motors, of which the following is a specification, reference being had to the drawings accompanying and forming a part of the same.

众所周知，我、尼古拉·特斯拉、来自奥匈帝国边境地区的利卡县的史密里安村，现在居住在纽约州纽约郡纽约市，在用于电动发电机的换向器方面已经发明了某种新的和有用的改进，以下是该发明一个说明书，必须参考随附的图纸，它已形成该说明书的一部分。

The invention relates to dynamo-electric machines or motors, and is an improvement in the devices for commutating and collecting the currents.

本发明涉及电动发电机或电动机，并且是对用于换向电流和收集电流的装置的一项改进。

The objects of the invention are, first, to avoid the sparking and the gradual wearing away or destruction of the commutator-segments and brushes or collectors resulting therefrom; second, to obviate the necessity of readjustment of the commutator or the brushes or collectors and other consequences of the wear of the same; third, to render practicable the construction of very large dynamo-electric machines and motors with the minimum number of commutator-segments, and fourth, to increase the efficiency and safety and reduce the cost of the machine.

本发明的目的是，首先，避免换向器分段和电刷或集电器所引起的火花和逐渐磨损或损坏；第二，避免了重新调整换向器或电刷或集电器的必要性以及它们磨损的其他后果；第三，使

得用最少数量的换向器分段建造非常大的电动发电机和电动机变得切实可行，第四，提高效率和安全性并降低机器的成本。

In carrying out my invention in a manner to accomplish these results I construct a commutator and the collectors therefore in two parts mutually adapted to one another, and, so far as the essential features are concerned, alike in mechanical structure. Selecting as an illustration a commutator of two segments adapted for use with an armature the coils or coil of which have but two free ends, connected respectively to the said segment, the bearing-surface is the face of a disk, and is formed of two metallic quadrant-segments and two insulating-segments of the same dimensions, and the face of the disk should be smoothed off, so that the metal and insulating segments are flush. The part which takes the place of the usual brushes, or what I term the “collector,” is a disk of the same character as the commutator and having a surface similarly formed with two insulating and two metallic segments. These two parts are mounted with their faces in contact and in such manner that the rotation of the armature causes the commutator to turn upon the collector, whereby the currents induced in the coils are taken off by the collector-segments and thence conveyed off by suitable conductors leading from the collector-segments. This is the general plan of the construction which I have invented. Aside from certain adjuncts, the nature and functions of which will be hereinafter set forth, this means of commutation will be seen to possess many important advantages. In the first place the short-circuiting and breaking of the armature-coil connected to the commutator-segments occur at the same instant, and from the nature of the construction this will be done with the greatest precision; secondly, the duration of both the break and that of the short-circuit will be reduced to a minimum. The first results in a reduction which amounts practically to a suppression of the spark, since the break and the short-circuit produce opposite effects in the armature-coil. The second has the effect of diminishing the destructive effect of a spark, since this would be in a measure proportioned to the duration of the spark, while lessening the duration of the short-circuit obviously increases the efficiency of the machine.

在以实现这些结果的方式实施我的发明时，我构造了一个换向器和分成相互适应的两部分的集电器，并且就基本特征而言，在机械结构上是相似的。选择适于与一个电枢一起使用的具有两个扇形分段的换向器作为示例，电枢的一个或多个线圈只有两个游离端，分别连接到所述扇形分段上，轴承表面是一个盘的表面，并且由两个金属四分体扇形分段和两个相同尺寸的绝缘扇形段形成，并且盘的表面应该平滑，使得金属和绝缘扇形段齐平。代替普通电刷的部分的（或者我称之为“集电器”的部分），是一个与换向器具有相同特性的圆盘，其表面同样由两个绝缘分段和两个金属分段组成。这两个部件以它们的表面相互接触的方式安装，使得电枢的旋转导致换向器在转动的同时倚靠着集电器，由此线圈中感应的电流被集电器分段取出，并因此被从集电器段引出的合适导体传送走。这是我发明的总体建造方案。除了某些附属物之外（其性质和功能将在下文中阐述），这种换向工具将被视为拥有许多重要的优势。首先，连接到换向器分段的电枢线圈的短路和断路同时发生，从结构的性质来看，这将以最大的精度完成；其次，断路的持续时间和短路的持续时间都将减到最短。第一种情况导致减少，实际上相当于抑制火花，因为断路和短路在电枢线圈中产生相反的效果。第二种情况具有减少火花的破坏性影响的效果，因为这将在一定程度上与火花的持续时间成正比，而减少短路的持续时间明显增加机器的效率。

The mechanical advantages will be better understood by referring to the accompanying drawings, in which—

通过参考附图，将更好地理解机械优势，其中—

Figure 1 is a central longitudinal section of the end of a shaft with my improved commutator carried thereon. Fig. 2 is a view of the inner or bearing face of the collector. Fig. 3 is an end view from the armature side of a modified form of commutator. Figs. 4 and 5 are views of details of Fig. 3. Fig. 6 is a longitudinal central section of another modification, and Fig. 7 is a sectional view of the same.

图 1 是带有我的改进后的换向器的一根轴的端部的中心纵向截面图。图 2 是集电器的内表面或倚靠面的视图。图 3 是从一个改进形式的换向器的电枢侧的端视图。图 4 和图 5 是图 3 的细节视图。图 6 是另一改进形式的纵向中心截面图，图 7 是同一形式的横向截面图。

A is the end of the armature-shaft of a dynamo-electric machine or motor.

A 是电动发电机或电动机的电枢轴的末端。

A' is a sleeve of insulating material around the shaft, secured in place by a screw, a', or by other suitable means.

A' 是围绕轴的绝缘材料套筒，通过一个螺钉 a' 或其他合适的方式固定到位。

The commutator proper is in the form of a disk which is made up of four segments, D D' G G', similar to those shown in Fig. 3. Two of these segments, as D D', are of metal and are in electrical connection with the ends of the coils on the armature. The other two segments are of insulating material. The segments are held in place by a band, B, of insulating material. The disk is held in place by friction or by screws, such as g' g', Fig. 3, which secure the disk firmly to the sleeve A'.

换向器本身是圆盘形式，由四个分段 D D' G G' 组成，类似于图 3 所示的那些分段。这些分段中的两个如 D D' 是金属的，并且与电枢上的线圈末端电连接。另外两个分段是绝缘材料。这些分段由绝缘材料带 B 固定到位。圆盘通过摩擦力或螺钉保持在适当位置，例如图 3 中的 g' g'，将圆盘牢固地固定在套筒 A' 上。

The collector is made in the same form as the commutator. It is composed of the two metallic segments E E' and the two insulating segments F F', bound together by a band, C. The metallic segment E E' are of the same or practically the same width or extent as the insulating segments or spaces of the commutator. The collector is secured to a sleeve, B', by screws g g, and the sleeve is arranged to turn freely on the shaft A. The end of the sleeve B' is closed by a plate, as f, upon which presses a pivot-pointed screw, h, adjustable in a spring, H, which acts to maintain the collector in close contact with the commutator and to compensate for the play of the shaft. Any convenient means is employed to hold the collector so that it may not turn with the shaft. For example, I have shown a slotted plate, K, which is designed to be attached to a stationary support, and an arm extending from the collector and carrying a clamping-screw, L, by which the collector may be adjusted and set to the desired position.

集电器的制造形式与换向器相同。它由两个金属分段 E E' 和两个绝缘段 F F' 组成，由一个带 C 连接在一起。金属分段 E E' 与换向器的绝缘分段或间隔具有相同或几乎相同的宽度或范围。集电器通过螺钉 g g 被固定在套筒 B' 上，套筒可在轴 A 上自由转动套筒 B' 的端部由一个

板 f 封闭，在该板 f 上压有可在弹簧 H 中调节的枢轴螺钉 h，该螺钉 h 用于保持集电器与换向器紧密接触并补偿轴的作用。采用任何方便的方法来固定集电器，使其不会随轴转动。例如，我已经展示出了一个槽板 K，该槽板被设计成附接到一个固定的支撑件上，并且一个臂从集电器延伸并且带有一个夹紧螺钉 L，通过该夹紧螺钉，集电器可以被调节并且设置到期望的位置。

I prefer in the form shown in Figs. 1 and 2 to fit the insulating-segments of both commutator and collector loosely and to provide some means—as, for example, light springs e e, secured to the bands A' B', respectively, and bearing against the segments—to exert a light pressure upon them and keep them in close contact and to compensate for wear. The metal segments of the commutator may be moved forward by loosening the screw a'.

我更喜欢采用图 1 和图 2 所示的形式，将换向器和集电器的绝缘分段进行松散地配合，并提供一些工具，例如分别固定在带 A' B' 上并倚靠在绝缘分段上的轻弹簧 e e，以便在它们上施加轻微的压力，使它们保持紧密接触，并补偿磨损。通过松开螺钉 a'，换向器的金属分段可以向前移动。

The circuit or line wires are led from the metal segments of the collector, being secured thereto in any convenient manner, the plan of connections being shown as applied to a modified form of the commutator in Fig. 6. The commutator and the collector in thus presenting two flat and smooth bearing-surfaces prevent by mechanical action the occurrence of sparks, and this is more effectively accomplished as is here done—that is to say, by the interposition of an insulating body between the separating plates or segments of the commutator and collector—than by any other mechanical devices of which I am aware.

电路或线路导线从集电器的金属分段引出，以任何方便的方式固定到集电器上，图 6 中展示了应用于换向器的改进形式的连接方案。换向器和集电器因此呈现两个平坦和光滑的倚靠表面，通过机械作用防止火花的发生，这可以更有效地实现，就像这里所做的那样——也就是说，通过在换向器和集电器的分隔板或分段之间插入一个绝缘体——比我知道的任何其他机械装置都要好。

The insulating-segments are made of some hard material capable of being polished and formed with sharp edges. Such materials as glass, marble, or soapstone may be advantageously used. The metal segments are preferably of copper or brass; but they may have a facing or edge of durable material—such as platinum or the like—where the sparks are liable to occur.

绝缘分段由一些能够被抛光并形成尖锐边缘的硬质材料制成。使用诸如玻璃、大理石或皂石的材料是有优势的。金属分段最好由铜或黄铜制成；但是它们的表面或边缘可以是耐用材料——例如铂或类似物——在那里容易产生火花。

In Fig. 3 a somewhat modified form of my invention is shown, a form designed to facilitate the construction and replacing of the parts. In this form the commutator and collector are made in substantially the same manner as previously described, except that the bands B C may be omitted. The four segment of each part, however, are secured to their respective sleeves by screws g' g', and one edge of each segment is cut away, so that small plates a b may be slipped into the spaces thus formed. Of

these plates $a a$ are of metal, and are in contact with the metal segments $D D'$, respectively. The other two, $b b$, are of glass or marble, and they are all preferably square, as shown in Figs. 4 and 5, so that they may be turned to present new edges should any edge become worn by use. Light springs d bear upon these plates and press those in the commutator toward those in the collector, and insulating-strips $c c$ are secured to the periphery of the disks to prevent the blocks from being thrown out by centrifugal action. These plates are, of course, useful at those edges of the segments only where sparks are liable to occur, and, as they are easily replaced, they are of great advantage. I prefer to coat them with platinum or silver.

在图 3 中，展示了我的发明的稍微修改后的形式，该形式被设计成便于部件的构建和更换。在这种形式中，除了带 $B C$ 可以省略之外，换向器和集电器以与前述基本相同的方式制成。然而，每个部分的四个分段通过螺钉 $g' g'$ 分别固定到它们各自的套筒上，并且每个分段的一个边缘被切掉，使得小板 a 和 b 可以滑入由此形成的空间中。这些板 $a a$ 是金属的，并且分别与金属分段 $D D'$ 接触。另外两个 $b b$ 由玻璃或大理石制成，并且它们都最好是正方形的，如图 4 和 5 所示，以便假如任何边缘由于使用而磨损的话，它们可以被转动以呈现新的边缘。轻弹簧 d 倚靠在这些极板上，将换向器中的板压向集电器中的板，绝缘条 $c c$ 被固定在圆盘的外周，以防止板被离心作用甩出。当然，这些板仅在容易产生火花的部分的边缘处有用，并且由于它们容易被替换，所以它们具有很大的优势。我更喜欢给它们镀上铂或银。

In Fig. 6 and 7 is shown the construction which I use when, instead of solid segments, a fluid is employed. In this case the commutator and collector are made of two insulating-disks, $S T$, and in lieu of the metal segments a space is cut out of each part, as at $R R'$, corresponding in shape and size to a metal segment. The two parts are fitted smoothly and the collector T held by the screws h and spring H against the commutator S . As in the other cases, the commutator revolves while the collector remains stationary. The ends of the coils are connected to binding-posts $s s$, which are in electrical connection with metal plates $t t$ within the recesses in the two parts $S T$. These chambers or recesses are filled with mercury, and in the collector part are tubes $W W$, with screws $w w$, carrying springs X and pistons X' , which compensate for the expansion and contraction of the mercury under varying temperatures, but which are sufficiently strong not to yield to the pressure of the fluid due to centrifugal action, and which serve as binding-posts.

在图 6 和 7 中，展示了当采用一种流体而不是固体分段时我所使用的结构。在这种情况下，换向器和集电器由两个绝缘盘 $S T$ 制成，取代金属分段的是从每个部分切出一个空间，如在 $R R'$ 处，在形状和尺寸上对应于一个金属分段。这两个部件被安装平稳，集电器 T 由螺钉 h 和弹簧 H 固定在换向器 S 上。与其他情况一样，换向器旋转，而集电器保持静止。线圈的末端连接到接线柱 $s s$ 上，接线柱 $s s$ 与两个部件 $S T$ 内的凹槽中的金属板 $t t$ 电连接。这些腔室或凹槽填充有汞，并且在集电器部件中的是具有螺钉 $w w$ 的管 $W W$ ，带有弹簧 X 和活塞 X' ，弹簧 X 和活塞 X' 在变化的温度下补偿汞的膨胀和收缩，但是它们足够坚固而不会屈服于由于离心作用产生的流体压力，并且它们被用作接线柱。

In all the above cases I have described commutators adapted for a single coil, and the device is particularly adapted to such purposes. The number of segments may be increased, however, or more than one commutator used with a single armature, as will be well understood.

在所有上述情况下，我已经描述了适用于单个线圈的换向器，并且该装置特别适用于这种目

的。然而，正如将被很好理解的那样，可以增加分段的数量，或者一个电枢使用一个以上的换向器。

Although I have shown the bearing-surface as planes at right angles to the shaft or axis, it is evident that in this particular the construction may be very greatly modified without departure from the invention.

虽然我已经展示了轴承表面是与轴或轴线成直角的平面，但是很明显，在不脱离本发明的情况下，可以对该特定结构进行非常大的修改。

Without confining myself, therefore, to the details of construction which I have shown in illustration of the invention, what I claim as new is—

因此，我并不局限于我在本发明的说明中所展示的结构细节，我所主张的新东西是—

1. In a dynamo-electric machine, the combination, with a commutator formed with conducting terminals or segments with intervening insulating-spaces, of a collector adapted to bear upon the surface of the commutator, and formed with conducting terminals or segments equal in extent to the insulating-space between the commutator-segments, as set forth.

1、在一个电动发电机中，一个集电器与一个换向器的组合，该换向器形成有导电终端或导电分段，导电终端或导电分段具有介于中间的绝缘空间，该集电器适于倚靠在换向器的表面上，并且形成有导电终端或导电分段，导电终端或导电分段的长度在一定程度上等于换向器分段之间的绝缘空间，如上所述。

2. The combination, with a commutator built or formed of alternate blocks or segments of conducting and insulating material, of a collector adapted to bear upon the surface of the commutator and formed of conducting blocks or segments of a width or extent equal to that of the insulating-segments of the commutator and separated by interposed blocks or segments of insulating material, as described.

2、一个集电器与一个换向器的组合，该换向器由导电材料和绝缘材料的交替区块或分段构成或形成，该集电器适于倚靠在换向器的表面上，并由宽度或范围等于换向器绝缘分段的宽度或范围的导电区块或分段形成，并由绝缘材料的插入区块或分段隔开，如所述。

3. The combination, with a commutator formed as a disk with alternate terminals or segments of conducting and insulating material, of a collector similarly formed and mounted with its face in contact with that of the commutator, as set forth.

3、一个集电器与一个换向器的组合，换向器形成为具有导电材料和绝缘材料的交替终端或分段的圆盘，集电器类似地形成和安装，其表面与换向器的表面接触，如前所述。

4. The combination, with a commutator having a bearing-surface formed of alternate sections of conducting and insulating material, of a collector with a similar and symmetrically formed bearing-surface and means for applying spring-pressure to force the two bearing-surfaces together, as set forth.

4、具有由导电材料和绝缘材料的交替部分所形成的倚靠面的一个换向器、具有一个相似且对称形成的倚靠面的集电器和用于施加弹簧压力来将两个倚靠面压在一起的组合,如前所述。

5. The combination, with a commutator and a collector the bearing-surfaces of which are identical in respect to the disposition of the conducting and insulating parts, of means for applying spring-pressure to maintain the two bearing-surfaces in contact and means for holding the collector against rotary movement, as set forth.

5、一个组合,它包括一个换向器和一个集电器,它们的倚靠面在导电部分和绝缘部分的布置方面相同、施加弹簧压力以保持两个倚靠面相互接触的工具和固定集电器防止旋转运动的组合,如前所述。

Signed by me this 21st day of April, 1887.

由我于 1887 年 4 月 21 日签署。

NIKOLA TESLA.

尼古拉·特斯拉

Witnesses:

ROBT. F. GAYLORD,

FRANK E. HARTLEY.

见证人:

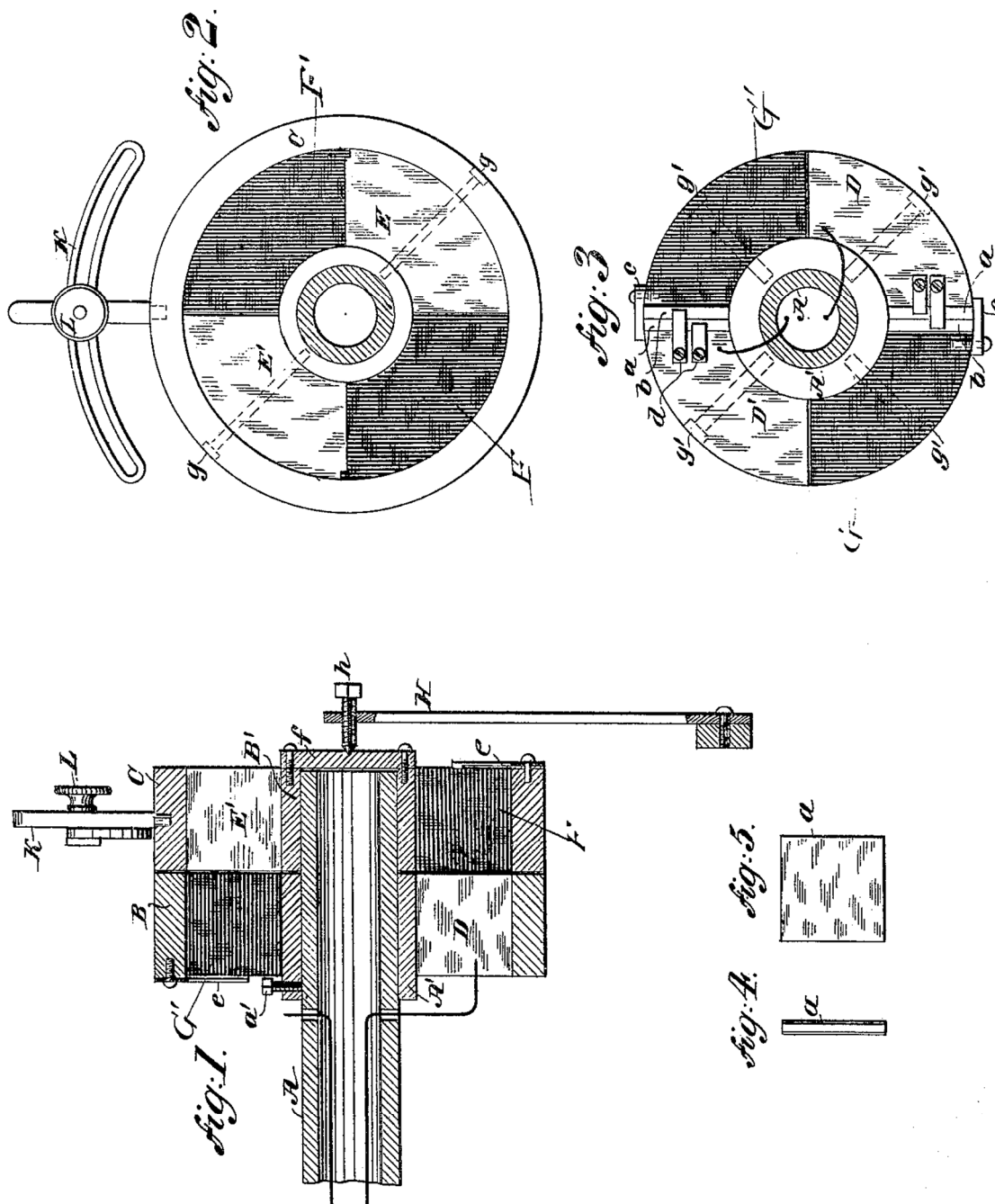
罗伯特·F·盖洛德、弗兰克·E·哈特利。

N. TESLA.

COMMUTATOR FOR DYNAMO ELECTRIC MACHINES.

No. 382,845.

Patented May 15, 1888.



WITNESSES:

Robt. F. Gaylord.
Robt. P. Harlow.

INVENTOR.

Nikola Tesla

BY

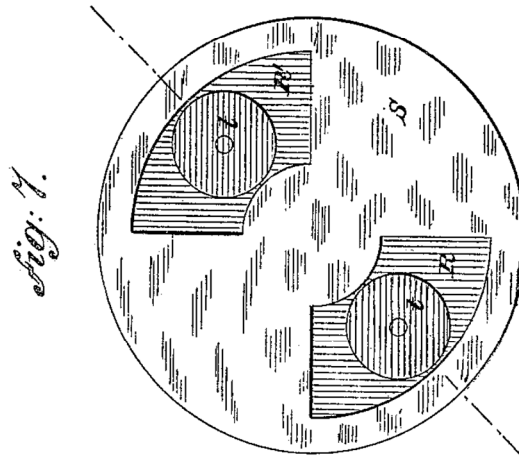
Duncan, ^{BY} Curtis & Page

ATTORNEYS.

2 Sheets—Sheet 2.

COMMUTATOR FOR DYNAMO ELECTRIC MACHINES.

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Robt. F. Gaylord.
Robt. P. Harlow.

INVENTOR,
Nikola Tesla.
BY
Drineau, Conter & Sage.
ATTORNEYS.

SYSTEM OF ELECTRICAL DISTRIBUTION.

配电系统

NIKOLA TESLA, OF NEW YORK, N. Y., ASSIGNOR TO THE TESLA ELECTRIC
COMPANY, OF SAME PLACE.

纽约州纽约市的尼古拉·特斯拉将专利权转让给纽约市的特斯拉电气公司

SPECIFICATION forming part of Letters Patent No. 390,413 dated October 2, 1888.

Application filed April 10, 1888. Serial No. 270,187. (No model.)

该说明书形成了颁发于 1888 年 10 月 2 日编号为 390,413 的专利证书的一部分。

申请于 1888 年 4 月 10 日提交。序列号为 270,187。(没有模型)

To all whom it may concern:

致所有相关人士:

Be it known that I, NIKOLA TESLA, a subject of the Emperor of Austria, from Smiljan, Lika, border country of Austria-Hungary, residing in the city, county, and State of New York, have invented certain new and useful Improvements in Systems of Electrical Distribution, of which the following is a specification, reference being had to the drawings accompanying and forming a part of the same.

众所周知，我、尼古拉·特斯拉、一位奥匈帝国的臣民，来自奥匈帝国边境地区的利卡县的史密里安村，现在居住在纽约州纽约郡纽约市，在配电系统方面已经发明了某些新的和有用的改进，以下是该发明一个说明书，必须参考随附的图纸，它已形成了该说明书的一部分。

In previous applications for patents made by me I have shown and described electrical systems for the transmission of power and the conversion and distribution of electrical energy, in which the motors and the transformers contain two or more coils or sets of coils, which were connected up in independent circuits with corresponding coils of an alternating-current generator, the operation of the system being brought about by the co-operation of the alternating currents in the independent circuits in progressively moving or shifting the poles or points of maximum magnetic effect of the motors or converters. In these systems, as I have described them, two independent conductors were employed for each of the independent circuits connecting the generator with the devices for converting the transmitted currents into mechanical energy or into electric currents of another character; but I have found that this is not always necessary, and that the two or more circuits may have a single return path or wire in common, with a loss, if any, which is so extremely slight that it may be disregarded entirely. For sake of illustration, if the generator have two independent coils and the motor two coils or two sets of coils in corresponding relations to its operative elements one terminal of each generator-coil is connected to the corresponding terminals of the motor coils through two independent conductors, while the opposite terminals of the respective coils are both connected to one return-wire.

在我以前的专利申请中，我已经展示和描述了用于电力传输和电能的转换和分配的电气系统，其中电动机和变压器包含两个或多个线圈或线圈组，它们在独立电路中与一个交流发电

机的相应线圈连接,该系统的运行是通过独立电路中的交流电在逐渐移动或转移电动机或转换器的磁极或最大磁效应点的过程中的共同作用而实现的。在这些系统中,正如我所描述的那样,每个独立电路都采用了两个独立的导体,用于将发电机与将传输的电流转换为机械能或其他特性的电流的设备连接起来。但我发现这并不总是必要的,两个或多个电路可以有一个共同的返回路径或导线,会有损耗,如果有的话,损耗非常轻微的,可以完全忽略不计。为了便于说明,如果发电机具有两个独立的线圈,而电动机具有与自身的有效组件成对应关系的两个线圈或两组线圈,则每个发电机线圈的一个终端通过两个独立的导体连接到电动机线圈的对应终端上,而各个线圈的相对终端都连接到一条回线上。

This invention is applicable to my system in various ways, as will be seen by reference to the drawings, in which—

本发明可以以各种方式应用到我的系统中,如参照附图所见,其中—

Figure 1 is a diagrammatic illustration of a generator and single motor constructed and electrically connected in accordance with the invention. Fig. 2 is a diagram of the system as it is used in operating motors or converters or both, in parallel or multiple arc. Fig. 3 illustrates diagrammatically the manner of operating two or more motors or converters, or both, in series.

图1是根据本发明构造和电连接的一个发电机和单个电动机的示意图。图2是该系统用于并联或多弧方式运行电动机或转换器或两者都有时的示意图。图3示意性地展示了串联操作两个或多个电动机或转换器或两者都有时的方式。

It is obvious that for purposes of this invention motors or transformers, which may be all designated as “converters,” are the same, and that either or both may be operated by the same system or arrangement of circuits.

显而易见的是,对于本发明的目的,电动机或变压器(它们都可以被称为“转换器”)是相同的,并且其中之一或两者可以由相同的系统或电路布置来运行。

Referring to Fig. 1, A A designate the poles of the field-magnets of a alternating-current generator, the armature of which, being in this case cylindrical in form and mounted on a shaft, C, is wound longitudinally with coils B B'. The shaft C carries three insulated contact-rings a b c, to two of which, as b c, one terminal of each coil, as e d, is connected. The remaining terminals, f g, are both connected to the third ring, a.

参见图1, A A 表示一个交流发电机的场磁铁的磁极,在这种情况下,该交流发电机的电枢是圆柱形,并且被安装在一个轴 C 上,该电枢上纵向缠绕有线圈 B B'。轴 C 带有三个被绝缘接触环 a b c, 每一个线圈的一个终端(如 e d) 都连接到这些接触环中的其中两个(如 b c)。其余的终端 f g, 都连接到第三个环 a 上。

A motor in this case is shown as composed of a ring, H, wound with four coils, I I J J, electrically connected, so as to co-operate in pairs; with a tendency to fix the poles of the ring at four points ninety degrees apart. Within the magnetic ring H is a disk or cylindrical core wound with two coils, G G', which may be connected to form two closed circuits. The terminals j k of the two sets or pairs of coils

are connected, respectively, to the binding-posts E' F', and the other terminals, h i, are connected to a single binding-post, D'. To operate the motor, three line-wires are used to connect the terminals of the generator with those of the motor.

在这种情况下，一个电动机被展示为由一个环 H 组成，该环上缠绕有四个电连接的线圈 I I J J，以便成对地协作；倾向于将环的极点固定在相隔 90 度的四个点上。在磁环 H 内是一个盘或圆柱形铁芯，上面缠绕有两个线圈 G G'，它们可以连接起来形成两个闭合电路。两组或两对线圈的终端 j k 分别连接到接线柱 E' F' 上，而另一个终端 h i 连接到单个接线柱 D' 上。为了运行电动机，用三根线路导线把发电机的终端和电动机的终端连接起来。

So far as the apparent action or mode of operation of this arrangement is concerned, the single wire D, which is, so to speak, a common return-wire for both circuits, may be regarded as two independent wires. In illustration, with the order of connection shown, coil B' of the generator is producing its maximum current and coil B its minimum; hence the current which passes through wire e, ring b, brush b', line-wire E, terminal E', wire j, coils I I, wire or terminal D', line-wire D, brush a', ring a, and the wire f, fixes the polar line of the motor midway between the two coils I I; but as the coil B' moves from the position indicated it generates less current, while coil B, moving into the field, generates more. The current from coil B passes through the devices and wires designated by the letters d, c, c', F, F', k, J J, i, D', D, a', a, and g, and the position of the poles of the motor will be due to the resultant effect of the currents in the two sets of coils—that is, it will be advanced in proportion to the advance or forward movement of the armature-coils. The movement of the generator-armature through one-quarter of a revolution will obviously bring coil B' into its neutral position and coil B into its position of maximum effect, and this shifts the poles ninety degrees, as they are fixed solely by coils B. This action is repeated for each quarter of a complete revolution.

就这种布置的明显作用或运行模式而言，可以说单根导线 D，也就是两个电路的公共回线，可以被视为两条独立的导线。在图中，按照所示的连接顺序，发电机的线圈 B' 正在产生最大的电流，线圈 B 正在产生最小电流；因此，流经导线 e、环 b、电刷 b'、线路导线 E、终端 E'、导线 j、线圈 I I、导线或终端 D'、线路导线 D、电刷 a'、环 a 和导线 f 的电流将电动机的磁极线固定在两个线圈 I I 的中途；但是当线圈 B' 从所示位置转移时，它产生的电流较少，而线圈 B 移动到磁场中时，产生的电流较多。来自线圈 B 的电流流经的设备和导线由字母 d、c、c'、F、F'、k、J、J、i、D'、D、a'、a 和 g 表示，电动机的磁极位置将取决于两组线圈中电流的合成效应，也就是说，它将与电枢线圈的前进或向前运动成比例地前进。发电机电枢经过四分之一圈的运动显然会将线圈 B' 带入电枢的中性位置，并将线圈 B 带入电枢的最大作用位置，这将磁极转移 90 度，因为它们仅由线圈 B 确定。这个动作在一个完整旋转的每四分之一圈中重复进行。

When more than one motor or other device is employed, they may be run either in parallel or series. In Fig. 2 the former arrangement is shown. The electrical device is shown as a converter, L, constructed as I have described in my application Serial No. 258,787, filed December 23, 1887. The two sets of primary coils p r are connected, respectively, to the mains F E, which are electrically connected with the two coils of the generator. The cross-circuit wires l m, making these connections, are then connected to the common return-wire D. The secondary coils p' p" are in circuits n o, including, for example, incandescent lamps. Only one converter is shown entire in this figure, the others being illustrated diagrammatically.

当使用一个以上的电动机或其他设备时，它们可以并联运行或串联运行。在图 2 中，展示了前一种布置。电气设备展示为一个转换器 L，其结构如我在 1887 年 12 月 23 日提交的序列号 258,787 的申请中所述。两组初级线圈 p r 分别连接到干线 FE，干线 FE 与发电机的两个线圈电气连接。形成这些连接的交叉电路导线 l m，然后连接到公共回线 D。次级线圈 p' p'' 在包含例如白炽灯的电路 n o 中。在该图中，只有一个转换器被完整地展示出，其他的只被示意性地展示。

When motors or converters are to be run in series, the two wires E F are led from the generator to the coils of the first motor or converter, then continued on to the next, and so on through the whole series, and are then joined to the single wire D, which completes both circuits through the generator. This is shown in Fig. 3, in which J I represent the two coils or sets of coils of the motors.

当电动机或转换器串联运行时，两根导线 E F 从发电机连接到第一个电动机或转换器的线圈，然后继续连接到下一个电动机或转换器的线圈，以此类推，贯穿所有的串联，然后连接到单根导线 D，导线 D 通过发电机完成两个电路。这在图 3 中展示出，其中 J I 表示电动机的两个线圈或两组线圈。

Obviously it is immaterial to the operation of the motor or equivalent device in Fig. 1 what order of connections is observed between the respective terminals of the generator or motor.

显然，在发电机或电动机的各个终端之间观察到什么样的连接顺序对于图 1 中电动机或等效装置的操作并不重要。

I have described the invention in its best and most practicable form of which I am aware; but there are other conditions under which it may be carried out. For example, in case the motor and generator each has three independent circuits, one terminal of each circuit is connected to a line-wire and the other three terminals to a common return-conductor. This arrangement will secure similar results to those attained with a generator and motor having but two independent circuits, as above described.

我已经以我所知道的最佳和最可行的形式描述了本发明；但是在其他条件下也可以执行本发明。例如，在电动机和发电机各自具有三个独立电路的情况下，每个电路的一个终端连接到一条线路导线，而其他三个终端连接到一个公共回路导体。如上所述，这种布置将确保获得的结果与仅具有两个独立回路的发电机和电动机获得的结果相似。

When applied to such machines and motors as have three or more induced circuits with a common electrical joint, the three or more terminals of the generator would be simply connected to those of the motor. Such forms of machines, when adapted in this manner to my system, I have, however, found to be less efficient than the others.

当应用于具有三个或更多的带有一个公共电接头的感应电路的机器和电动机时，发电机的三个或更多的终端将简单地连接到电动机的终端。然而，这种形式的机器，当以这种方式适应我的系统时，我发现效率低于其他系统。

The invention is applicable to machines and motors of various types, and according to circumstances and conditions readily understood, with more or less efficient results. I do not therefore limit myself to

any of the details of construction of the apparatus herein shown.

本发明适用于各种类型的机器和电动机，并且根据容易理解的环境和条件，具有或多或少的效率结果。因此，我并不局限于这里所示的装置的任何结构细节。

What I claim is—

我主张的是—

1. The combination, with a generator having independent current-generating circuits and a converter or converters having independent and corresponding circuits, of independent conductors connecting one terminal of each generator-circuit with a corresponding terminal of the motor and a single conductor connecting the remaining generator and converter terminals, as set forth.

1、存在一个组合，它包括：具有独立的电流产生电路的一个发电机和具有独立的和相应的电路的一个或多个转换器；将每个发电机电路的一个终端与电动机的相应终端连接的独立导体；连接其余的发电机和转换器终端的单个导体，如上所述。

2. The combination, with a generator having independent current-generating circuits and a converter or converters having independent and corresponding circuits, of independent line or connecting circuits formed in part through a conductor common to all, as set forth.

2、存在一个组合，它包括：具有独立的电流产生电路的一个发电机和具有独立的和相应的电路的一个或多个转换器；独立线路或连接电路部分地由所述的一个公共导体形成，如上所述。

3. The system of electrical distribution herein set forth, consisting of the combination, with an alternating-current generator having independent generating-circuits and electro-magnetic motors or converters provided with corresponding energizing-circuits, of line wires or conductors connecting the coils of the motors or converters, respectively, in series with one terminal of each circuit of the generator, and a single return wire or conductor connecting the said conductors with the other terminal of the generator, as set forth.

3、本文所述的配电系统，由以下部分组成：具有独立的发电电路的一个交流发电机和配有相应励磁电路的电磁电动机或转换器；将电动机或转换器的线圈与发电机的每个电路的一个终端分别串联连接的电路导线或者导体；以及将所述导体与发电机的另一个终端连接的单个回线或导体，如上所述。

NIKOLA TESLA.

尼古拉·特斯拉

Witnesses:

ROBT. F. GAYLORD, FRANK E. HARTLEY.

见证人:

罗伯特·F·盖洛德、弗兰克·E·哈特利。

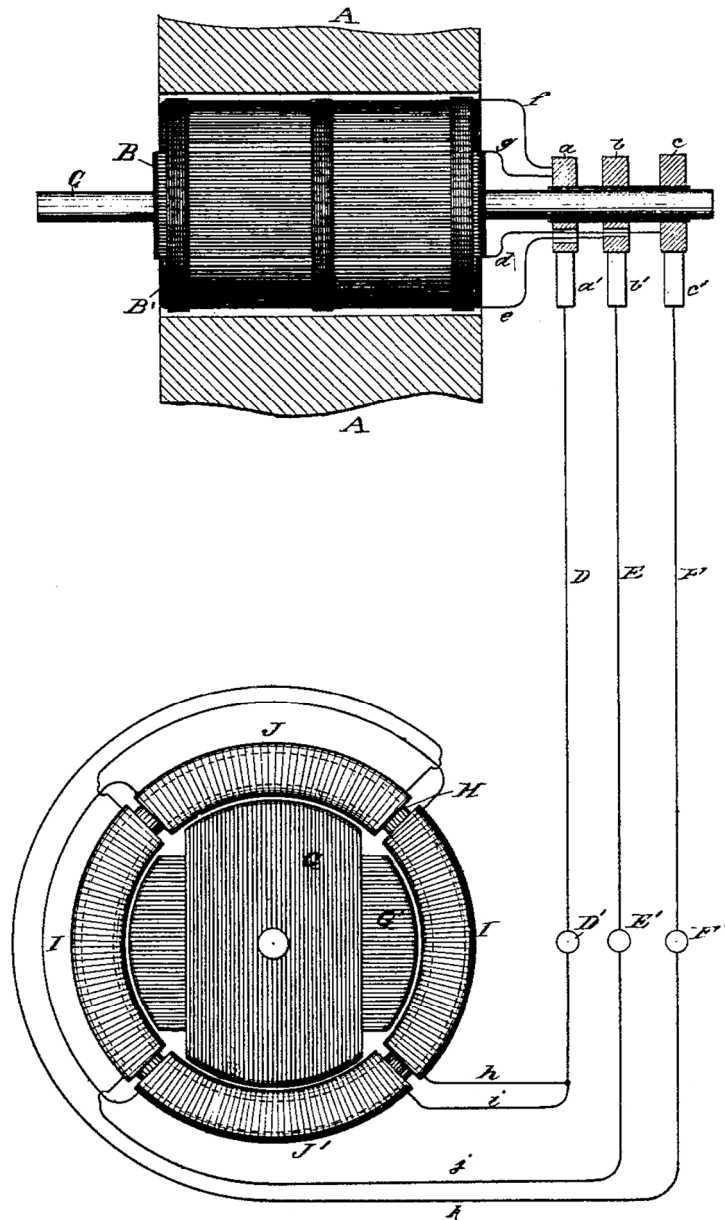
N. TESLA.

SYSTEM OF ELECTRICAL DISTRIBUTION.

No. 390,413.

Patented Oct. 2, 1888.

Fig. 1



WITNESSES:

Raphael Netzer
Franco B. Murosky

INVENTOR

Nikola Tesla

BY

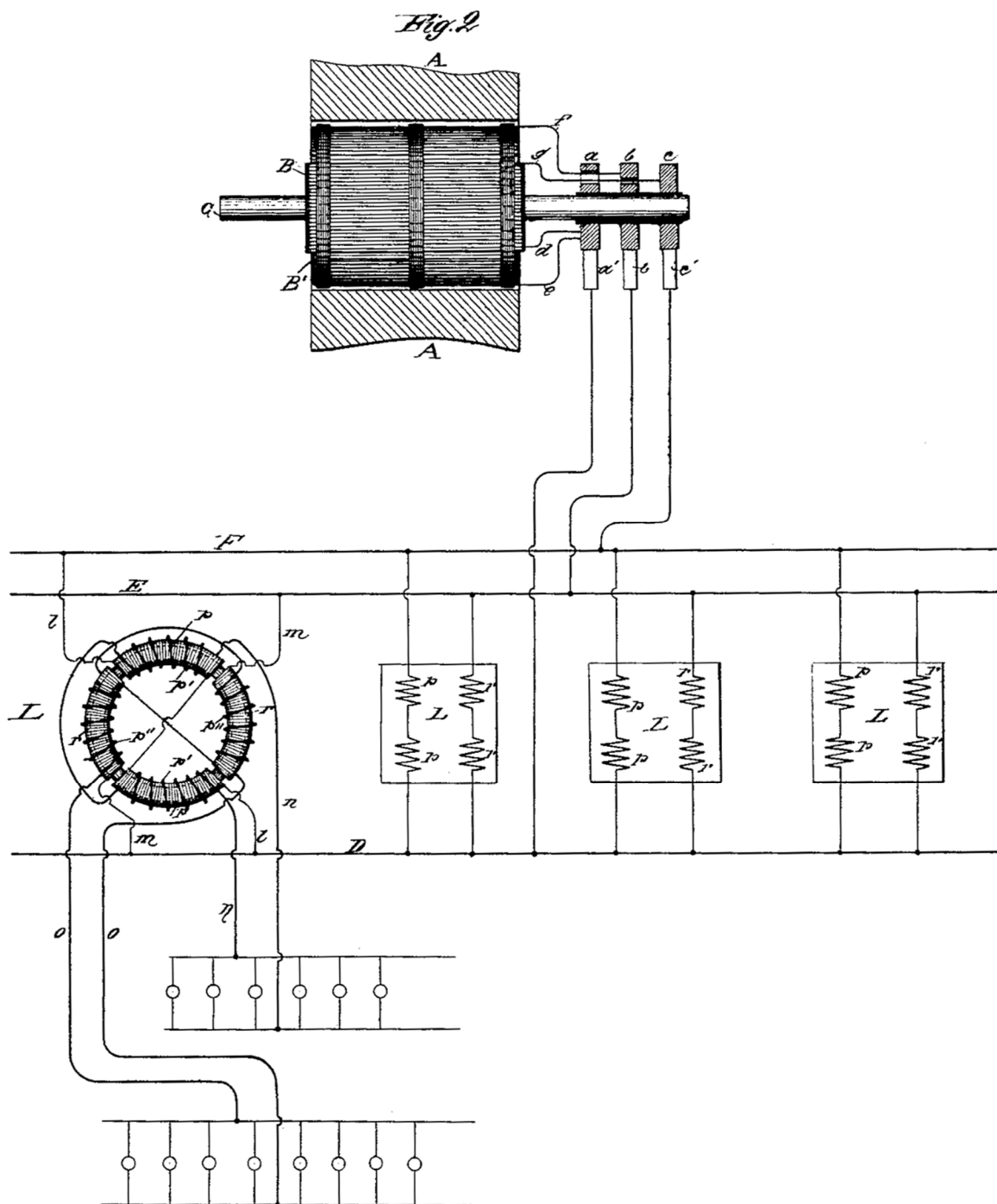
Duncan, Curtis & Page
ATTORNEY

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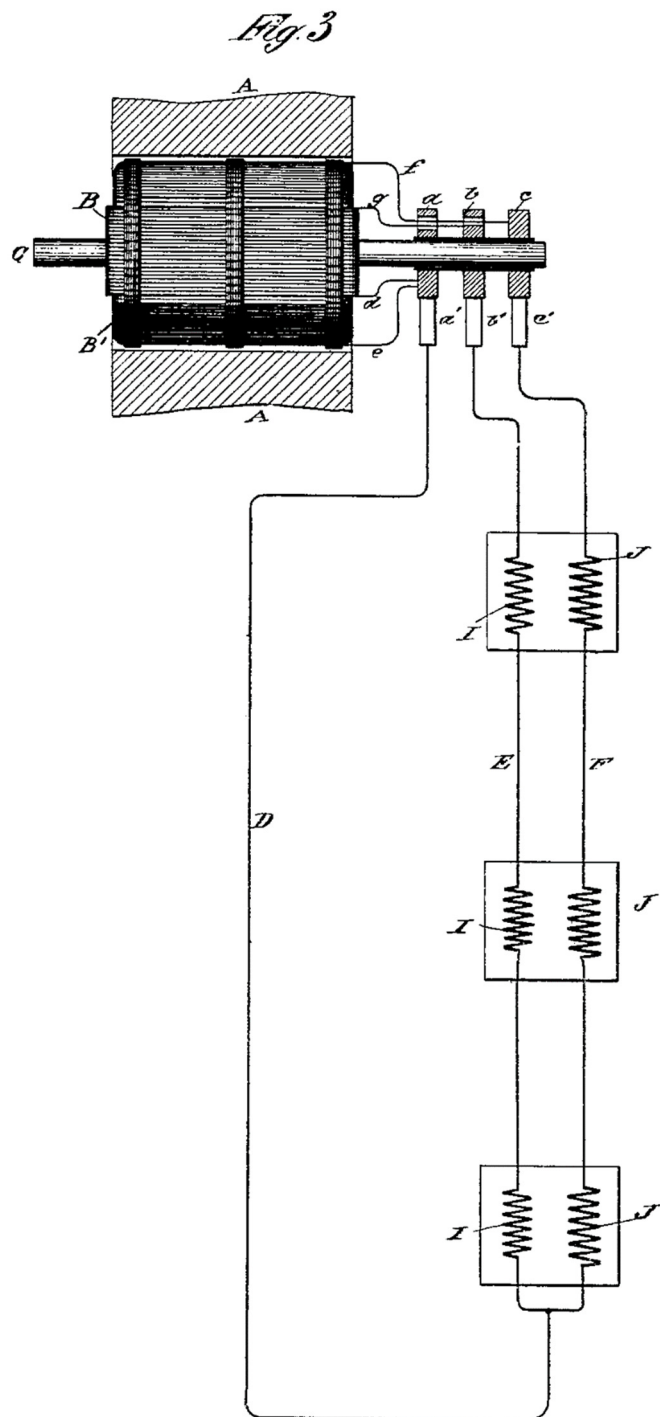
BY
Duncan Curtis & Page
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N. TESLA.

SYSTEM OF ELECTRICAL DISTRIBUTION.

No. 390,413.

Patented Oct. 2, 1888.



WITNESSES:

Raphael Netter
Franc B. Muntzky

INVENTOR

Nikola Tesla

BY

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ATTORNEYS.

DYNAMO-ELECTRIC MACHINE.

电动发电机

SPECIFICATION forming part of Letters Patent No. 390,414 dated October 2, 1888.

Application filed April 23, 1888. Serial No. 271,626. (No model.)

该说明书形成了颁发于 1888 年 10 月 2 日编号为 390,414 的专利证书的一部分。

申请于 1888 年 4 月 23 日提交。序列号为 271,626。(没有模型)

To all whom it may concern:

致所有相关人士:

Be it known that I, NIKOLA TESLA, a subject of the Emperor of Austria, from Smiljan, Lika, border country of Austria-Hungary, now residing at New York, in the county and State of New York, have invented certain new and useful Improvements in Dynamo-Electric Machines, of which the following is a specification, reference being had to the drawings accompanying and forming a part of the same.

众所周知,我、尼古拉·特斯拉、一位奥匈帝国的臣民,来自奥匈帝国边境地区的利卡县的史密里安村,现在居住在纽约州纽约郡纽约市,在电动发电机方面已经发明了某些新的和有用的改进,以下是该发明一个说明书,必须参考随附的图纸,它已形成了该说明书的一部分。

In certain patents granted to Charles F. Peck and myself—notably in Patents No. 381,968 and No. 382,280, May 1, 1888—I have shown and described a plan of constructing and operating motors, transformers, and the like, by alternating currents conveyed through two or more independent circuits from a generator having such relation to the motors or transformers as to produce therein a progressive movement of the magnetic poles or lines of force. In the said applications the descriptions and illustrations of the generators were confined to those types of alternating current machine in which the current generating coils are independent or separate; but I have found that the ordinary forms of continuous current dynamos now in use may be readily and cheaply adapted to my system, or utilized both as continuous and alternating current generators with but slight changes in their construction. The mode of effecting this forms the substance of my present application.

在授予查尔斯·F·佩克和我本人的某些专利中——特别是在 1888 年 5 月 1 日的第 381,968 号和第 382,280 号专利中——我已经展示和描述了一种构建和运行电动机、变压器的方案,该方案是依靠来自发电机的两个或多个独立电路传送的交流电,该发电机与电动机或变压器的关系使得在其中产生磁极或磁力线的渐进运动。在所述申请中,发电机的描述和说明被局限于那些类型的交流电动机,其中产生电流的线圈是独立的或分开的;但我已经发现现在使用的普通形式的恒向电流发电机可以很容易和便宜地适用于我的系统,或用作恒向电流发电机和交流发电机,但在结构上略有变化。实现这一点的方式形成了我目前申请的实质。

Generally stated, the plan pursued by me in carrying out this invention is as follows: On the shaft of a given generator, either in place of or in addition to the regular commutator, I secure as many pairs of insulated collecting-rings as there are circuits to be formed. Now, it will be understood that in the

operation of any dynamo-electric generator the currents in the coils in their movement through the field of force undergo different phases—that is to say, at different positions of the coils the currents have certain directions and certain strengths—and that in my improved motors or transformers it is necessary that the currents in the energizing-coils should undergo a certain order of variations in strength and direction. Hence, the further step—viz., the connection between the induced or generating coils of the machine and the contact-rings from which the currents are to be taken off—will be determined solely by what order of variations of strength and direction in the currents is desired for producing a given result in the electrical translating device. This may be accomplished in various ways; but in the drawings I have given typical instances only of the best and most practicable ways of applying the invention to three of the best-known types of machines, in order to illustrate the principle and to enable anyone skilled in the art to apply the invention in any other case or under any modified conditions which the circumstances of particular cases may require.

一般来说，我在实施本发明时所追求的方案如下：在给定的一个发电机的轴上，取代常规换向器或除常规换向器之外，我固定尽可能多的被绝缘的集电环对，来形成电路。现在，可以理解的是，在任何电动发电机的运行中，线圈中的电流在穿过力场的运动中经历不同的相位——也就是说，在线圈的不同位置，电流具有特定的方向和特定的强度——并且在我改进的电动机或变压器中，激励线圈中的电流必须经历强度和方向的特定顺序的变化。因此，进一步的步骤——即机器的感应线圈或发电线圈与从中取出电流的接触环之间的连接将仅由在电转换装置中产生给定结果所需的电流强度和电流方向的变化顺序来决定。这可以通过多种方式实现；但是在附图中，我仅给出了将本发明应用于三种最知名类型的机器的最佳的和最可行的典型实例，以便说明原理并使本领域技术人员能够在任何其他情况下或在可能需要特定情况环境的任何修改条件下应用本发明。

Figure 1 is a diagram illustrative of the mode of applying the invention to the well-known type of closed or continuous circuit machines. Fig. 2 is a similar diagram containing an armature with separate coils connected diametrically, or what is generally called an “open-circuit” machine. Fig. 3 is a diagram showing the application of the invention to a machine the armature-coils of which have a common joint.

图 1 是说明将本发明应用于众所周知类型的闭合的或连续电路的机器的模式的示意图。图 2 是一个类似的图，包含一个电枢，带有径向连接的独立线圈，或者通常称为“开路”机器。图 3 是展示应用本发明的一个机器的示意图，它的电枢线圈具有公共接头。

Referring to Fig. 1, let A represent one of my improved motors or transformers, which, for convenience, I shall designate a “converter,” which consists of an annular core, B, wound with four independent coils, C and D, those diametrically opposite being connected together so as to co-operate in pairs in establishing free poles in the ring, the tendency of each pair being to fix the poles at ninety degrees from the other. There may be an armature, E, within the ring, which is wound with coils closed upon themselves. The object is to pass through coils C D currents of such relative strength and direction as to produce a progressive shifting or movement of the points of maximum magnetic effect around the ring, and to thereby maintain a rotary movement of the armature. I therefore secure to the shaft F of the generator four insulated contact-rings, a b c d, upon which I cause to bear the collecting-brushes a' b' c' d', connected by wires G G H H, respectively, with the terminal of coils C and D.

参考图 1，让 A 代表我的一个改进后的电动机或变压器，为了方便起见，我将指定一个“转换器”，它包括一个环形铁芯 B，其上缠绕有四个独立的线圈，C 和 D，完全径向相对的线圈连接在一起，以便成对地合作，在环中建立自由极点，每对线圈的倾向是确定彼此成 90 度的磁极点。在一个圆环内可以有一个电枢 E，它由自我闭合的线圈缠绕其上。其目的是使线圈 C D 中流过这种相对强度和相对方向的电流，从而使环周围的最大磁效应点逐渐移动，从而保持电枢的旋转运动。因此，我将四个被绝缘的接触环 a b c d 固定到发电机的轴 F 上，在这些接触环上，我使集电刷 a' b' c' d' 通过导线 G G H H 分别与线圈 C 和 D 的终端连接。

Assume, for the sake of illustration, that the coils D D are to receive the maximum and coils C C at the same instant the minimum current, so that the polar line may be midway between the coils D D, the rings a b would therefore be connected to the continuous armature-coil at its neutral points with respect to the field or the point corresponding with that of the ordinary commutator-brushes, and between which exists the greatest difference of potential, while rings c d would be connected to two points in the coil, between which exists no difference of potential. The best results will be obtained by making these connections at points equidistant from one another, as shown. These connections are easiest made by using wires L between the rings and the loops or wires J, connecting the coil I to the segments of the commutator K. When the converters are made in this manner, it is evident that the phases of the currents in the sections of the generator-coil will be reproduced in the converter coils. For example, after turning through an arc of ninety degrees the conductors L L, which before conveyed the maximum current, will receive the minimum current by reason of the change in the position of their coils, and it is evident that for the same reason the current in said coils has gradually fallen from the maximum to the minimum in passing through the arc of ninety degrees. In this special plan of connections the rotation of the magnetic poles of the converter will be synchronous with that of the armature-coils of the generator; and the result will be the same, whether the energizing-circuits are derivations from a continuous armature-coil or from independent coils, as in my previous devices.

为了说明起见，假设线圈 D D 即将接受最大电流，在同一时刻线圈 C C 接受最小电流，因此极线可以在线圈 D D 的中间，因此环 a b 将在相对于磁场的中性点或在普通换向器电刷的中性点对应的点处与连续电枢线圈相连，并且在这两个点之间存在最大的电位差，而环 c d 将连接到线圈中的两个点，在这两个点之间不存在电位差。如图所示，在彼此等距的点上进行这些连接将获得最佳结果。这些连接最容易通过在环和环路或导线 J 之间使用导线 L 来实现，将线圈 I 连接到换向器 K 的分段上。当转换器以这种方式制造时，显然发电机线圈不同部分中的电流相位将在转换器线圈中再现。例如，在转过 90 度的弧之后，之前传送最大电流的导体 L L 将由于其线圈位置的变化而接受最小的电流，显然，由于同样的原因，在经过 90 度的弧时，所述线圈中的电流已经从最大值逐渐下降到最小值。在这种特殊的连接方案中，转换器磁极的旋转将与发电机电枢线圈的旋转同步；结果将是相同的，无论激励电路是来自一个连续的电枢线圈还是来自独立线圈，就像我以前的设备一样。

I have shown in Fig. 1, in dotted lines, the brushes M M in their proper normal position. In practice these brushes may be removed from the commutator and the field of the generator excited by an external source of current; or the brushes may be allowed to remain on the commutator and to take off a converted current to excite the field, or to be used for other purposes.

我已经在图 1 中用虚线展示了处于其正常位置的电刷 M M。在实践中，这些电刷可以从换向器和由一个外部电流源激励的发电机磁场中移除；或者可以允许电刷保留在换向器上，并

取出转换后的电流来激励磁场，或者用于其他目的。

In a certain well-known class of machines the armature contains a number of coils the terminals of which connect to commutator segments, the coils being connected across the armature in pairs. This type of machine is represented in Fig. 2. In this machine each pair of coils goes through the same phases as the coils in some of the generators I have shown, and it is obviously only necessary to utilize them in pairs or sets to operate one of my converters by extending the segments of the commutators belonging to each pair of coils and causing a collecting-brush to bear on the continuous portion of each segment. In this way two or more circuits may be taken off from the generator, each including one or more pairs of sets of coils, as may be desired.

在某种众所周知的机器中，电枢包含多个线圈，线圈的终端连接到换向器分段上，线圈成对地跨接在电枢上。这种类型的机器如图 2 所示。在该机器中，每对线圈经历与我已经展示的一些发电机中的线圈相同的相位，并且通过延长属于每对线圈的换向器分段，并使集电刷依靠在每个段的连续部分上，显然只需要成对或成组地利用线圈就能运行我的一个转换器。以这种方式，可以从发电机中取出两个或更多个电路，每个电路包括一对或多对线圈组，这可能是需要的。

In Fig. 2 I I represent the armature-coils, T T the poles of the field-magnet, and F the shaft carrying the commutators, which are extended to form continuous portions a b c d. The brushes bearing on the continuous portions for taking off the alternating currents are represented by a' b' c' d'. The collecting-brushes, or those which may be used to take off the direct current, are designated by M M. Two pairs of the armature-coils and their commutators are shown in the figure as being utilized; but all may be utilized in a similar manner.

在图 2 中 II 代表电枢线圈，T T 代表场磁铁的磁极，F 代表装有换向器的轴，它们延伸形成连续的 a b c d 部分。倚靠在连续部分上用于取出交流电的电刷用 a' b' c' d' 表示。集电刷，或那些可以用来取出直流电的电刷，被指定为 M M。图中展示了两对电枢线圈和它们的正被使用的换向器；但是都可以以类似的方式使用。

There is another well-known type of machine in which three or more coils, A' B' C', on the armature have a common joint, the free ends being connected to the segments of a commutator. This form of generator is illustrated in Fig. 3. In this case each terminal of the generator is connected directly or in derivation to a continuous ring, a b c, and collecting-brushes a' b' c', bearing thereon, take off the alternating currents that operate the motor. It is preferable in this case to employ a motor or transformer with three energizing-coils, A" B" C", placed symmetrically with those of the generator, and the circuits from the latter are connected to the terminals of such coils either directly—as when they are stationary—or by means of brushes e' and contact-rings e. In this, as in the other cases, the ordinary commutator may be used on the generator, and the current taken from it utilized for exciting the generator field-magnets or for other purposes.

还有另一种众所周知的机器，其中电枢上的三个或三个以上的线圈 A' B' C' 有一个公共接头，游离端连接到换向器分段上。这种形式的发电机如图 3 所示。在这种情况下，发电机的每一个终端都直接或间接连接（通过线圈进行连接）到一个连续的环 a b c 上，环上倚靠着集电刷 a' b' c'，用于取出驱动电动机的交流电。在这种情况下，最好使用具有三个励磁线圈 A" B" C"

C"的电动机或变压器，A" B" C"与发电机的线圈对称放置，后者的电路既可以直接连接到这些线圈的终端上——当它们静止时——或者通过电刷 c'和接触环 c 连接。在这种和在其他情况下一样的情况下，普通的换向器可以用在发电机上，从它获取的电流用于励磁发电机的场磁体或用于其他目的。

These examples serve to illustrate the principle of the invention. It will be observed that in any case it is necessary only to add the continuous contact or collecting rings and to establish the connections between them and the appropriate coils.

这些实施例用于说明本发明的原理。可以观察到，在任何情况下，只需要增加连续的接触环或集电环，并在它们和适当的线圈之间建立连接。

It will be understood that this invention is applicable to other types of machine—as, for example, those by which the induced coils are stationary and the brushes and magnet revolve; but the manner of its application is obvious to one skilled in the art.

应当理解，本发明可应用于其它类型的机器，例如，感应线圈静止而电刷和磁体旋转的机器；但是其应用方式对于本领域技术人员来说是显而易见的。

Having now described my invention, what I claim is—

现在我已经描述了我的发明，我主张的是—

1. The combination, with a converter having independent energizing-coils, of a continuous or direct current dynamo or magneto machine, and intermediate-circuits permanently connected as suitable points to the induced or generating coils of the generator, as herein set forth.

1、一个恒向或直流的发电机或磁电机与具有独立励磁线圈的一个转换器的组合，以及作为合适的点永久连接到发电机的感应或发电线圈的中间电路，如本文所述。

2. The combination, with a converter provided with independent energizing-circuits, of a continuous or direct current generator provided with continuous collecting-rings connected in derivation to the armature-coils to form the terminal of circuits corresponding to those of the converter, as herein set forth.

2、一个恒向或直流的发电机与配备有独立激励电路的转换器的组合，该发电机配备有连续集电环，该连续集电环以间接方式连接到电枢线圈上，以形成与转换器的电路终端相对应的电路终端，如本文所述。

NIKOLA TESLA.

尼古拉·特斯拉

Witnesses:

ROBT. F. GAYLORD,

FRANK B. MURPHY.

见证人：罗伯特·F·盖洛德、弗兰克·B·墨菲。

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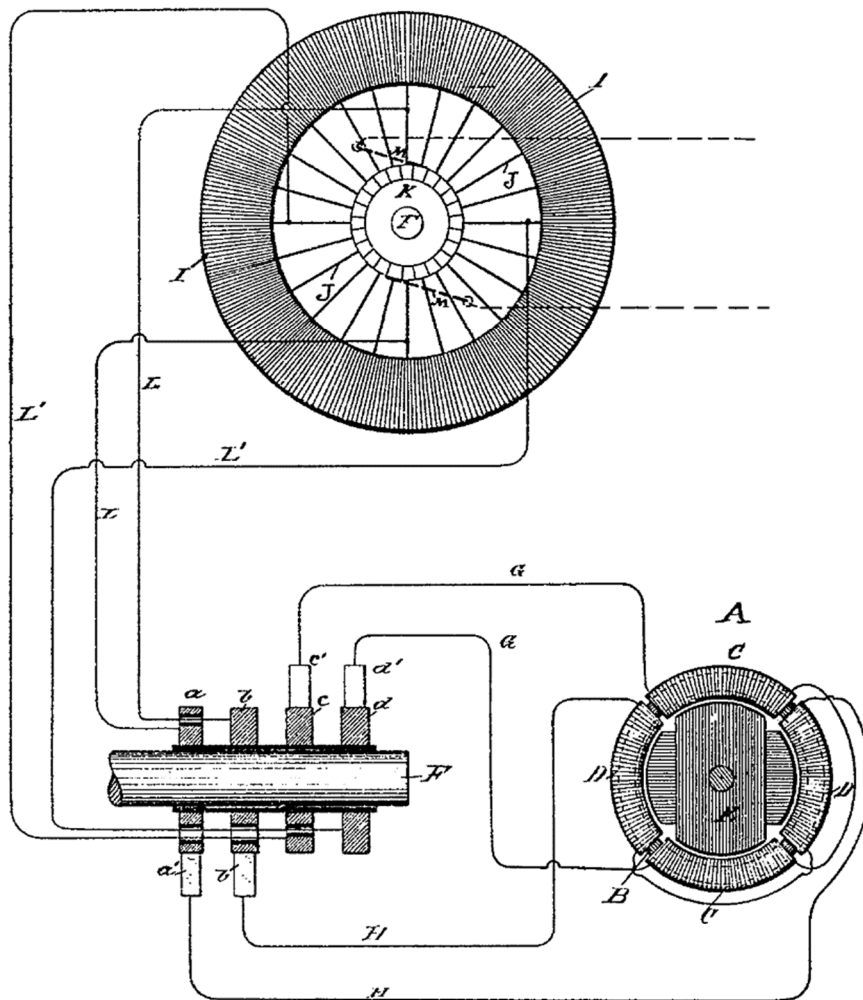
N. TESLA.

DYNAMO ELECTRIC MACHINE.

No. 390,414.

Patented Oct. 2, 1888.

Fig. 1



WITNESSES:

Raphael Netter
Frank C. Hartley

INVENTOR

Nikola Tesla

BY

Duncan, Carter & Hag
ATTORNEYS

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(No Model.)

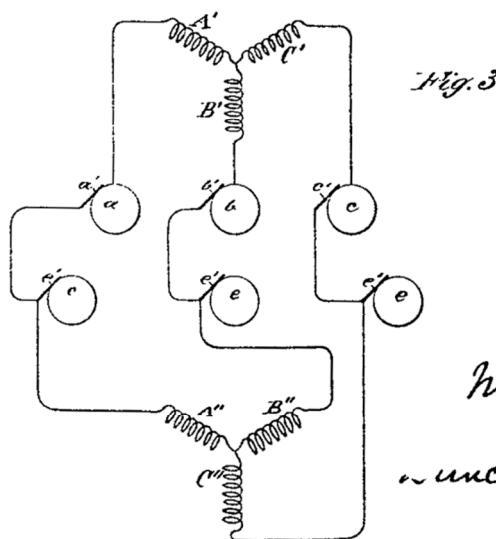
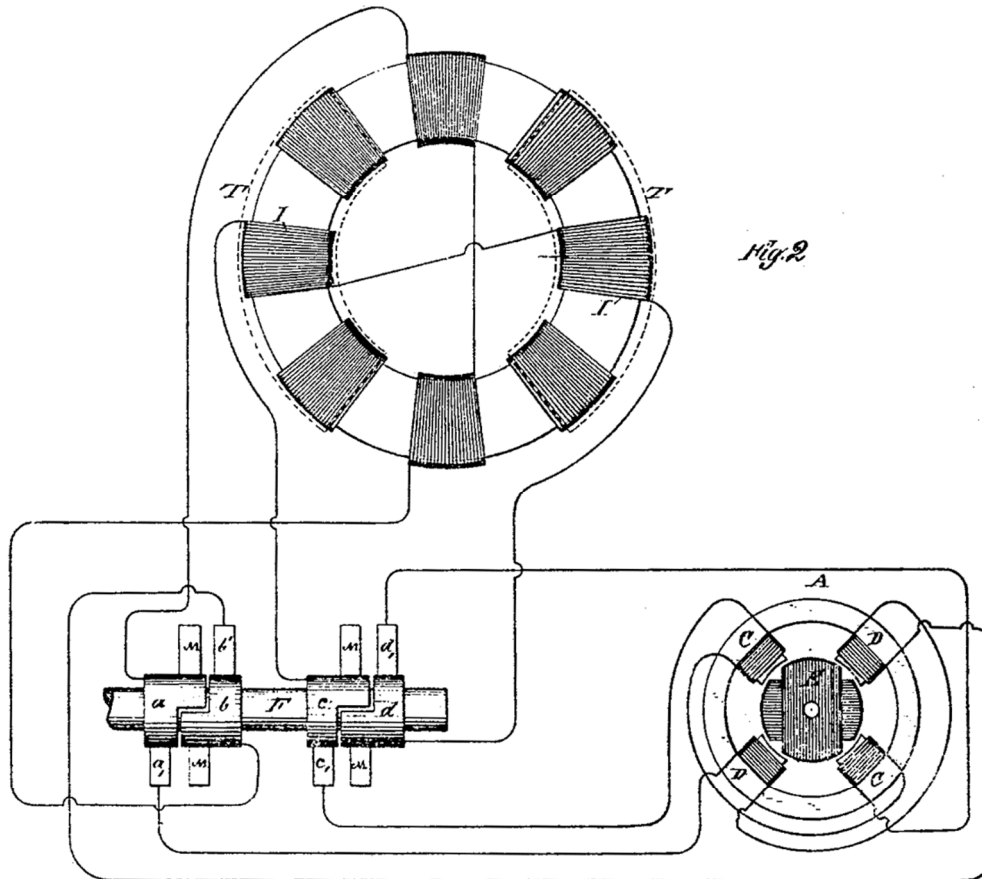
2 Sheets—Sheet 2.

N. TESLA.

DYNAMO ELECTRIC MACHINE.

No. 390,414.

Patented Oct. 2, 1888.



WITNESSES:
Raphael Netter
Frank C. Hartley

INVENTOR
Nikola Tesla
BY
Wm. C. Curtis & Co.
ATTORNEYS

DYNAMO-ELECTRIC MACHINE OR MOTOR.

电动发电机或电动机

SPECIFICATION forming part of Letters Patent No. 390,415 dated October 2, 1888.

Application filed May 15, 1888. Serial No. 273,994. (No model.)

该说明书形成了颁发于 1888 年 10 月 2 日编号为 390,415 的专利证书的一部分。

申请于 1888 年 5 月 15 日提交。序列号为 273,994。(没有模型)

To all whom it may concern:

致所有相关人士:

Be it known that I, NIKOLA TESLA, a subject of the Emperor of Austria, from Smiljan, Lika, border country of Austria-Hungary, now residing at New York, in the county and State of New York, have invented certain new and useful Improvements in Dynamo-Electric Machines and Motors, of which the following is a specification, reference being had to the drawings accompanying and forming a part of the same.

众所周知，我、尼古拉·特斯拉、一位奥匈帝国的臣民，来自奥匈帝国边境地区的利卡县的史密里安村，现在居住在纽约州纽约郡纽约市，在电动发电机和电动机方面已经发明了某些新的和有用的改进，以下是该发明一个说明书，必须参考随附的图纸，它已形成了该说明书的一部分。

This invention is an improvement in the construction of dynamo or magneto electric machines or motors, the improvement consisting in a novel form of frame and field-magnet which renders the machine more solid and compact as a structure, which requires fewer parts, and which involves less trouble and expense in its manufacture.

本发明是对发电机或磁电机或电动机的结构的改进，这种改进在于一种新型的框架和场磁体的形式，这种新型的框架和场磁体使得机器作为一个结构更加坚固和紧凑，这种结构需要更少的部件，并且在其制造中涉及更少的麻烦和费用。

The invention is applicable to generators and motors generally, not only to those which I have described in former patents, and which have independent circuits adapted for use in my patented alternating current system, but to other continuous or alternating current machines, such as have heretofore been more generally used.

本发明通常适用于发电机和电动机，不仅适用于我在以前的专利中描述过的、具有适用于我的专利的交流系统的独立电路的发电机和电动机，而且适用于其他恒向或交流的电动机，例如迄今为止更普遍使用的电动机。

In the drawings hereto annexed, which illustrate my improvements, Figure 1 shows the machine in side elevation. Fig. 2 is a vertical sectional view of the field-magnets and frame and an end view of the armature; and Fig. 3 is a plan view of one of the parts of the frame and the armature, a portion of the latter being cut away.

在附图中，说明了我的改进，图 1 展示了机器的侧视图。图 2 是场磁体和框架的垂直截面图以及电枢的端视图；图 3 是框架和电枢的部件的平面图，电枢的一部分被切掉。

I cast the field-magnets and frame in two parts. These parts are identical in size and shape, and each consists of the solid plates or ends A B, from which project inwardly the cores C D and the side bars or bridge-pieces, E F. The precise shape of these parts is largely a matter of choice—that is to say, each casting, as shown, forms an approximately-rectangular frame; but it may obviously be more or less oval, round, or square without departure from the invention. I also prefer to reduce the width of the side bars, E F, at the center and to so proportion the parts that when the frame is put together the spaces between the pole-pieces will be practically equal to the arcs which the surfaces of the poles occupy.

我铸造的场磁体和框架分为两部分。这些部分在大小和形状上是相同的，并且每个都由实心板或端部 A B 组成，从实心板或端部 A B 向内突出形成铁芯 C D 和边条或桥接件 E F。这些部件的精确形状很大程度上是一个选择的问题——也就是说，如图所示，每个铸件形成一个近似矩形的框架；但是在不脱离本发明的情况下，它显然可以或多或少是椭圆形、圆形或正方形。我也喜欢减少侧杆在中心的宽度 E F 的宽度，并使各部分的比例相称，当框架组装在一起时，极靴之间的空间实际上等于磁极表面占据的弧长。

The bearings G for the armature-shaft are cast in the side-bars, E F. The field-coils are either wound on the pole-pieces or, preferably, wound on a form and then slipped on over the ends of the pole-pieces. The lower part or casting is secured to a suitable base after being finished off. The armature K on its shaft is then mounted in the bearings of the lower casting and the other part of the frame placed in position, dowel-pins L or any other means being used to secure the two parts in proper position.

用于电枢轴的轴承 G 被铸造在边条 E F 中，励磁线圈或者缠绕在极靴上，或者最好缠绕在线圈架上，然后套在极靴的端部。完成后，将较低部分或铸件固定在合适的底座上。然后，电枢 K 在其轴上，电枢轴被安装在较低铸件的轴承中，框架的另一部分被放置在适当的位置，接合销 L 或任何其他装置被用于将这两个部分固定在适当的位置。

In order to secure an easier fit I cast the side bars, E F, and end-pieces, A B, so that slots M are formed when the two parts are put together.

为了确保更容易的配合，我铸造了边条 E F 和尾段 A B，这样当两个部件放在一起时就形成了沟槽 M。

This machine possesses many advantages. For example, I magnetize the cores alternately, as indicated by the characters N S, and it will be seen that the magnetic circuit between the poles of each part of a casting is completed through the solid iron side bars. The bearings for the shaft are located at the neutral points of the field, so that the armature-core is not affected by the magnetic condition of the field.

这台机器有许多优点。举个例子，我把铁芯交替磁化，铁芯用字符 NS 表示，就会看到一个铸件的各部分磁极之间的磁路是通过实心铁边条完成的。轴的轴承位于磁场的中性点，因此电枢铁芯不受磁场条件的影响。

My improvement is not restricted to the use of four pole-pieces, as it is evident that each pole-piece could be divided or more than four formed by the shape of the casting.

我的改进并不局限于使用四个极靴，因为很明显，每个极靴可以分开，或者由铸件的形状形成四个以上的极靴。

What I claim is—

我主张的是—

1. A dynamo or magneto electric machine or motor the frame of which is built up of two castings, each consisting of end plates with pole-pieces extending inwardly therefrom and connecting side bars, as set forth.

1、一种发电机或磁电机或电动机，其框架由两个铸件构成，每个铸件由端板构成，端板具有从自身向内延伸的极靴并连接边条，如上所述。

2. A frame for generators or motors built up of two superposed castings, each consisting of a rectangular frame with pole-pieces extending inwardly from its ends, as set forth.

2、用于发电机或电动机的一个框架，由两个重叠的铸件组成，每个铸件包括一个矩形框架，磁极靴从自身端部向内延伸，如上所述。

3. A frame and field-magnet for generators and motors built up of two rectangular castings having pole-pieces extending inwardly from their ends, the faces of said pole-pieces being curved to afford clearance for the armature and provided with energizing-coils, as set forth.

3、一种用于发电机和电动机的框架和场磁体，由两个矩形铸件构成，具有从其端部向内延伸的极靴，所述极靴的表面被弯曲来为电枢提供间隙，并配备有励磁线圈，如前所述。

NIKOLA TESLA.

尼古拉·特斯拉

Witnesses:

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罗伯特·F·盖洛德、弗兰克·E·哈特利。

(No Model.)

N. TESLA.

DYNAMO ELECTRIC MACHINE OR MOTOR.

No. 390,415.

Patented Oct. 2, 1888.

Fig. 1

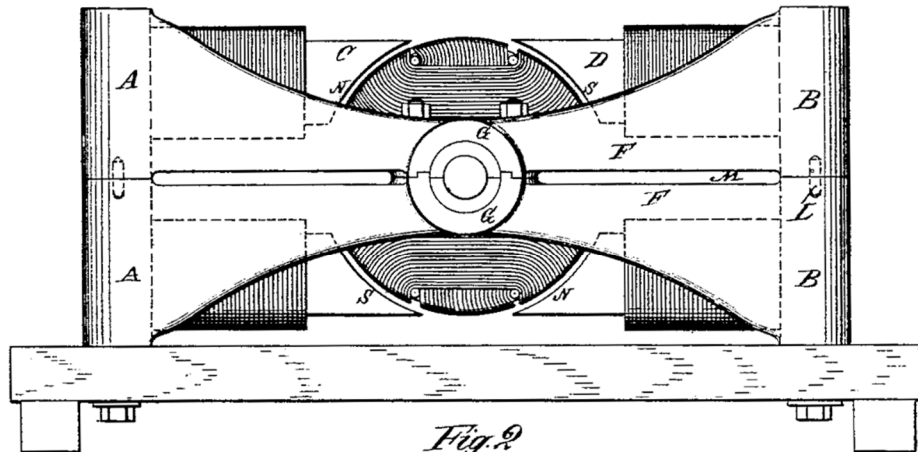


Fig. 2

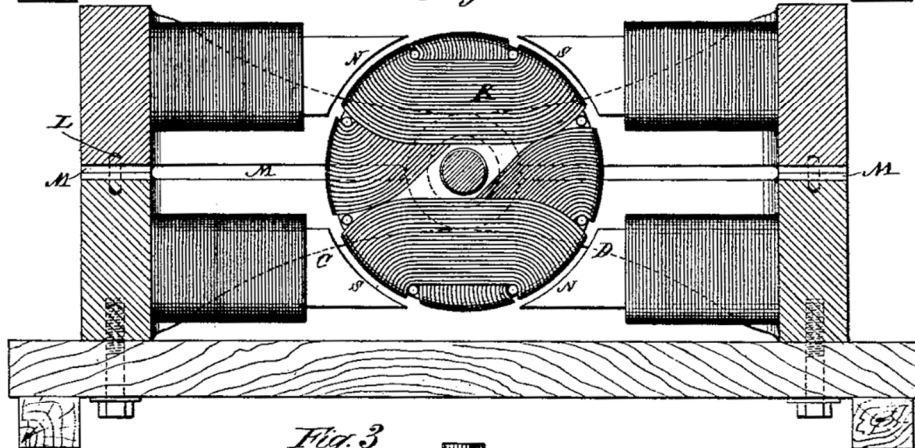
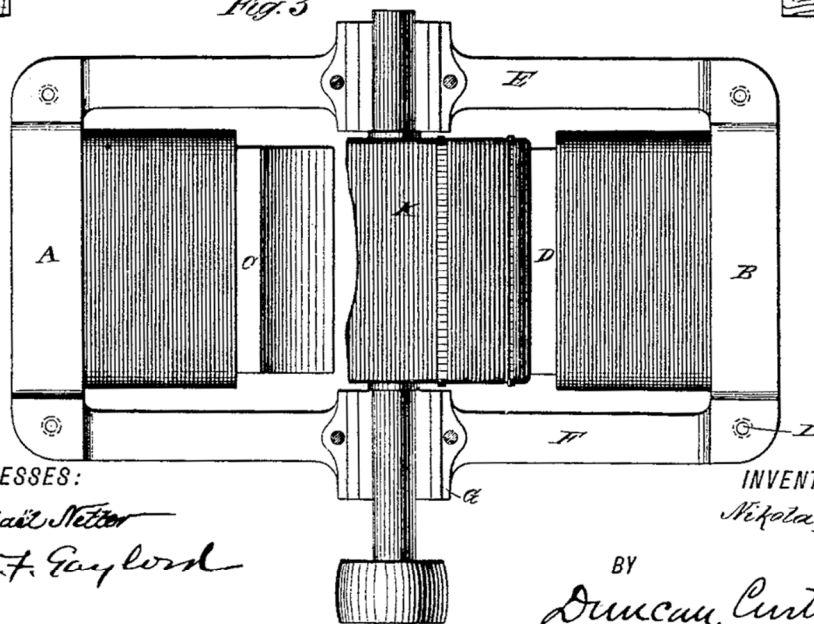


Fig. 3



WITNESSES:

Raphael Netter
Robert F. Gaylord

INVENTOR

Nikola Tesla

BY

Duncan, Curtis & Page
ATTORNEYS

DYNAMO-ELECTRIC MACHINE.

电动发电机

SPECIFICATION forming part of Letters Patent No. 390,721 dated October 9, 1888.

Application filed April 28, 1888. Serial No. 272,153. (No model.)

该说明书形成了颁发于 1888 年 10 月 9 日编号为 390,721 的专利证书的一部分。

申请于 1888 年 4 月 28 日提交。序列号为 272,153。(没有模型)

To all whom it may concern:

致所有相关人士:

Be it known that I, NIKOLA TESLA, a subject of the Emperor of Austria, from Smiljan, Lika, border country of Austria-Hungary, now residing at New York, in the county and State of New York, have invented certain new and useful Improvements in Electric Generators, of which the following is a specification, reference being had to the drawings accompanying and forming a part of the same.

众所周知,我、尼古拉·特斯拉、一位奥匈帝国的臣民,来自奥匈帝国边境地区的利卡县的史密里安村,现在居住在纽约州纽约郡纽约市,在电动发电机方面已经发明了某些新的和有用的改进,以下是该发明一个说明书,必须参考随附的图纸,它已形成了该说明书的一部分。

My present invention relates, chiefly, to the alternating-current system invented by me and described in prior patents, notably Nos. 381,968 and 382,280, of May 1, 1888, in which the motors or transformers, or generally the converters, are operated by a progressive shifting or movement of their magnetic poles produced by the co-operative action of independent magnetizing-coils through which pass alternating currents in proper order and direction. In my said system, as I have heretofore shown, I employed a generator of alternating currents in which there were independent induced or generating coils corresponding to the energizing-coils of the converter, and the relations of the generator and converters were generally such that the speed of rotation of the magnetic poles of the converter equaled that of the armature of the generator.

我的发明主要涉及由我发明并在现有专利中描述的交流系统,特别是 1888 年 5 月 1 日的第 381,968 号和第 382,280 号专利,其中电动机或变压器,或通常的转换器,通过由独立的磁化线圈的协同作用来产生这些机器的磁极的渐进转移或运动来运行,交流电以适当的顺序和方向通过独立的磁化线圈。在我的所述系统中,如前所述,我采用了一个交流发电机,该发电机中有独立的感应线圈或发电机线圈,对应于转换器的励磁线圈,发电机和转换器的关系通常是这样的,转换器磁极的转速等于发电机电枢的转速。

To secure the greatest efficiency, it is necessary to run the machines at a high speed, and this is true not only of those generators and motors which are particularly adapted for use in my system, but of others. The practicability of running at very high speeds, however, particularly in the case of large generators, is limited by mechanical conditions, in seeking to avoid which I have devised various plans for operating

the system under efficient conditions, although running the generator at a comparatively low rate of speed.

为了确保最大的效率，有必要使机器高速运转，这不仅适用于那些特别适合在我的系统中使用的发电机和电动机，而且适用于在其他系统使用的发电机和电动机。然而，在非常高的速度运行的实用性，特别是在大型发电机的情况下，受到机械条件的限制，为了寻求避免这种情况，尽管发电机以相对较低的速度运行，我已经设计了各种方案来在有效的条件下运行系统。

My present invention consists of another way of accomplishing this result, which in certain respects presents many advantages. According to the invention, in lieu of driving the armature of the generator at a high rate of speed, I produce a rotation of the magnetic poles of one element of the generator and drive the other at a different speed, by which similar results are obtained to those secured by a rapid rotation of one of the elements.

我的发明包括实现该结果的另一种方式，该方式在某些方面具有许多优点。根据本发明，取代以高速率驱动发电机的电枢，我产生发电机的一个组件的磁极的旋转，并以一个不同的速度驱动另一个组件，通过这种方式获得与通过组件之一的快速旋转所获得的结果相似的结果。

I shall describe this invention by reference to the diagram drawing hereto annexed.

我将参照附图描述本发明。

The generator which supplies the current for operating the motors or transformers consists in this instance of a subdivided ring or annular core wound with four diametrically-opposite coils, E E'. Within the ring is mounted a cylindrical armature-core wound longitudinally with two independent coils, F F', the ends of which lead, respectively, to two pairs of insulated contact or collecting-rings, D D' G G', on the armature-shaft. Collecting-brushes d d' g g' bear upon these rings, respectively, and convey the currents through the two independent line-circuits M M'. In the main-line there may be included one or more motors or transformers, or both. If motors be used, they are constructed in accordance with my invention with independent coils or sets of coils J J', included, respectively, in the circuits M M'. These energizing-coils are wound on a ring or annular field or on pole-pieces thereon, and produce by the action of the alternating currents passing through them a progressive shifting of the magnetism from pole to pole. The cylindrical armature H of the motor is wound with two coils at right angles, which form independent closed circuits.

在这种情况下，为电动机或变压器供电的发电机由一个被细分的环或环形铁芯组成，铁芯上缠绕着四个径向相对的线圈。环内安装有一个圆柱形电枢铁芯，纵向缠绕有两个独立的线圈 F F'，线圈的末端分别通向电枢轴上的两对被绝缘的接触环或集电环 D D' G G'。集电刷 d d' g g' 分别倚靠在这些环上，并通过两个独立的线路 M M' 输送电流。在干线中，可以包含一个或多个电动机或变压器，或者两者都包含。如果使用电动机，它们根据我的发明被构建成具有独立的线圈或线圈组 J J'，分别被包含在电路 M M' 中。这些励磁线圈缠绕在一个环或环状磁场上或环的极靴上，并通过流经它们的交流电的作用产生从一个磁极到另一个磁极的磁性渐进转移。该电动机的圆柱形电枢 H 上绕有两个成直角的线圈，形成独立的闭合电路。

If transformers be employed, I connect one set of the primary coils, as N N, wound on a ring or annular core, to one circuit, as M', and the other primary coils, N' N', to the circuit M. The secondary coils K K' may then be utilized for running groups of incandescent lamps P P'.

如果使用变压器，我将一组初级线圈，如 N N，缠绕在一个环或环形铁芯上，连接到一个电路，如 M'，而另一组初级线圈，如 N' N'，连接到电路 M。然后次级线圈 K K'可以用于运行多组白炽灯 P P'。

With the generator I employ an exciter. This consists of two poles, A A, of steel permanently magnetized, or of iron excited by a battery or other generator of continuous currents, and a cylindrical armature-core mounted on a shaft, B, and wound with two longitudinal coils, C C'. One end of each of these coils is connected to the collecting-rings b c, respectively, while the other ends are both connected to a ring, a. Collecting-brushes, b' c' bear on the rings b c, respectively, and conductors L L convey the currents therefrom through the coils E and E' of the generator. L' is a common return-wire to brush a'. Two independent circuits are thus formed, one including coils C of the exciter and E E of the generator, the other coils C' of the exciter and E' E' of the generator. It results from this that the operation of the exciter produces a progressive movement of the magnetic poles of the annular field-core of the generator, the shifting or rotary movement of said poles being synchronous with the rotation of the exciter-armature. Considering the operative conditions of a system thus established, it will be found that when the exciter is driven so as to energize the field of the generator the armature of the latter, if left free to turn, would rotate at a speed practically the same as that of the exciter. If under such conditions the coils F F', of the generator-armature be closed upon themselves or short-circuited, no currents, at least theoretically, will be generated in the said armature-coils. In practice I have observed the presence of slight currents, the existence of which is attributable to more or less pronounced fluctuations in the intensity of the magnetic poles of the generator-ring. So, if the armature-coils F F' be closed through the motor, the latter will not be turned as long as the movement of the generator-armature is synchronous with that of the exciter or of the magnetic poles of its field. If, on the contrary, the speed of the generator-armature be in any way checked, so that the shifting or rotation of the poles of the field becomes relatively more rapid, currents will be induced in the armature-coils. This obviously follows from the passing of the lines of force across the armature-conductors. The greater the speed of rotation of the magnetic poles relatively to that of the armature the more rapidly the currents developed in the coils of the latter will follow one another, and the more rapidly the motor will revolve in response thereto, and this continues until the armature-generator is stopped entirely, as by a brake, when the motor, if properly constructed, runs at the same speed with which the magnetic poles of the generator rotate.

对于发电机，我使用了一个励磁机。它由两个磁极 A A（磁极 A A 由永久磁化的钢制成，或者由铁制成并由电池或其他恒向电流发电机励磁），以及一个安装在轴 B 上的圆柱形电枢铁芯（其上缠绕有两个纵向线圈 C C'）组成。这些线圈每一个的一端分别连接到集电环 b c 上，而另一端都连接到一个集电环 a 上。集电刷 b' c' 分别倚靠在环 b c 上，导体 L L 通过发电机的线圈 E 和 E' 传送电流。L' 是电刷 a' 的公共回线。这样就形成了两个独立的电路，一个包含了励磁机的线圈 C 和发电机的线圈 E E，另一个包含了励磁机的线圈 C' 和发电机的线圈 E' E'。由此产生的结果是，励磁机的运行产生了发电机的环形励磁铁芯的磁极的渐进运动，所述磁极的转移或旋转运动与励磁机电枢的旋转同步。考虑到这样建立的一个系统的操作条件，将会发现，当励磁机被驱动以励磁发电机的磁场时，如果发电机的电枢自由转动，则电

枢将以实际上与励磁机相同的速度旋转。如果在这种情况下，发电机电枢的线圈 FF' 自身闭合或被短路，至少理论上，在所述电枢线圈中不会产生电流。在实践中我已经观察到存在微弱的电流，它的存在可归因于发电机环的磁极强度或多或少的明显波动。因此，如果电枢线圈 FF' 通过电动机被闭合，只要发电机电枢的运动与励磁机或其磁场磁极的运动同步，电动机就不会转动。相反，如果发电机电枢的速度以任何方式被抑制，由此磁场磁极的移动或旋转变得相对更快，电流将在电枢线圈中感应出电流。这显然是由磁力线穿过电枢导体引起的。磁极的旋转速度相对于电枢的旋转速度越大，电枢的线圈中产生的电流将越快相互跟随，并且电动机将响应于此并且旋转得越快，这持续到电枢-发电机完全停止，如果电动机构建适当，当电动机以与发电机的磁极旋转相同的速度运行时，电动机的完全停止就如同通过一个制动器一样。

The effective strength of the currents developed in the armature-coils of the generator is dependent upon the strength of the currents energizing the generator and upon the number of rotations per unit of time of the magnetic poles of the generator; hence the speed of the motor-armature will depend in all cases upon the relative speeds of the armature of the generator and of its magnetic poles. For example, if the poles are turned two thousand times per unit of time and the armature is turned eight hundred, the motor will turn twelve hundred times, or nearly so. Very slight differences of speed may be indicated by a delicately-balanced motor.

发电机电枢线圈中产生的电流的有效强度取决于激励发电机的电流强度和发电机磁极在单位时间的转数；因此，电动机电枢的速度将在所有情况下取决于发电机电枢及其磁极的相对速度。例如，如果磁极在单位时间内转动 2000 次，电枢转动 800 次，电动机将转动 1200 次，或接近如此。非常细微的速度差异可以通过微妙平衡的电动机来指示。

Let it now be assumed that power is applied to the generator-armature to turn it in a direction opposite to that in which its magnetic poles rotate. In such case the result would be similar to that produced by a generator the armature and field-magnets of which are rotated in opposite directions, and by reason of these conditions the motor-armature will turn at a rate of speed equal to the sum of the speeds of the armature and magnetic poles of the generator, so that a comparatively low speed of the generator-armature will produce a high speed in the motor.

现在假设给发电机电枢通电，使其向与磁极旋转方向相反的方向转动。在这种情况下，结果将类似于由一个发电机产生的结果，发电机的电枢和场磁体以相反的方向旋转，并且由于这些条件，电动机电枢将以等于发电机的电枢和磁极的速度之和的速度旋转，使得发电机电枢的相对低的速度将在电动机中产生高的速度。

It will be observed in connection with this system that on diminishing the resistance of the external circuit of the generator-armature by checking the speed of the motor or by adding translating devices in multiple arc in the secondary circuit or circuits of the transformer the strength of the current in the armature-circuit is greatly increased. This is due to two causes: first, to the great differences in the speeds of the motor and generator, and, secondly, to the fact that the apparatus follows the analogy of a transformer, for, in proportion as the resistance of the armature or secondary circuits is reduced, the strength of the currents in the field or primary circuits of the generator is increased and the currents in the armature augmented correspondingly. For similar reasons the currents in the armature-coils of the generator increase very rapidly when the speed of the armature is reduced when running in the same

direction as the magnetic poles or conversely.

结合该系统可以观察到,在通过抑制电动机的速度或通过变压器的次级电路中用并联的方式增加转换装置来减小发电机电枢的外部电路的电阻时,电枢电路中的电流强度大大增加。这是由于两个原因:第一,由于电动机和发电机速度的巨大差异,第二,该设备类似于变压器,因为随着电枢或次级电路的电阻减小,发电机的磁场或初级电路中的电流强度增加,电枢中的电流相应地增大。出于类似的原因,当电枢在与磁极相同或相反的方向运行时,如果电枢的速度降低,发电机电枢线圈中的电流会非常迅速地增加。

It will be understood from the above description that the generator-armature may be run in the direction of the shifting of the magnetic poles, but more rapidly, and that in such case the speed of the motor will be equal to the difference between the two rates.

从上面的描述可以理解,发电机电枢可以在磁极移动的方向上运行,但是更快,并且在这种情况下,电动机的速度将等于两个速率之间的差。

In many applications to electrical conversion and distribution this system possesses great advantages both in economy, efficiency, and practicability.

在电力转换和配电的许多应用中,该系统在经济性、效率和实用性方面都有很大的优势。

What I claim is—

我主张的是—

1. The combination, with an alternating-current generator having independent energizing or field and independent induced or armature coils, of an alternating-current exciter having generating or induced coils corresponding to and connected with the energizing-coils of the generator, as set forth.

1、一个交流励磁机与具有独立的励磁线圈或场线圈以及独立的感应线圈或电枢线圈的交流发电机的组合,该交流励磁机具有与发电机励磁线圈相对应并相连的发电线圈或感应线圈,如上所述。

2. In an alternating-current generator, the combination of the elements named and cooperatively associated in the following manner: a field-magnet wound with independent coils each connected with a source of alternating currents, whereby the magnetic poles produced by said coils will be progressively shifted or moved through the field, and an armature-core wound with independent coils, each having terminals from which currents are delivered to the independent external circuits.

2、在一个交流发电机中,以下列方式命名并协同关联的组件的组合:一个由独立线圈缠绕的场磁体,每个线圈与交流电源相连,由此由所述线圈产生的磁极将在磁场中逐渐转移或移动;一个由独立线圈缠绕的电枢铁芯,每个线圈都有端子,电流从这些端子输送到独立的外部电路。

3. The system of electrical distribution consisting of the combination, with an alternating-current

generator having independent energizing-coils and an armature wound with independent induced coils, of an alternating-current exciter having induced coils corresponding to and connected with the energizing-coils of the generator, and one or more electrical converters having independent inducing or energizing coils connected with the corresponding armature coils of the generator, as herein set forth.

3、在一个配电系统中存在一个组合，它包括具有独立励磁线圈的交流发电机和缠绕有独立感应线圈的电枢；一个交流励磁机，具有与发电机励磁线圈对应并连接的感应线圈；一个或多个电转换器，具有与发电机的相应电枢线圈连接的独立的施感线圈或励磁线圈，如上所述。

4. The combination, with an alternating-current generator having a field-magnet wound with independent energizing-coils and an armature adapted to be rotated within the field produced by said magnet, of an exciter having induced or generating coils corresponding to and connected with the energizing-coils of the generator, as set forth.

4、存在一个组合，它包括一个交流发电机，它具有被缠绕有独立励磁线圈的场磁体和适于在所述磁体产生的磁场内旋转的电枢；一个励磁机，它具有对应于发电机励磁线圈并与之连接的感应线圈或发电线圈，如上所述。

NIKOLA TESLA.

尼古拉·特斯拉

Witnesses:

ROBT. F. GAYLORD,

PARKER W. PAGE.

见证人:

罗伯特·F·盖洛德、帕克·W·佩奇。

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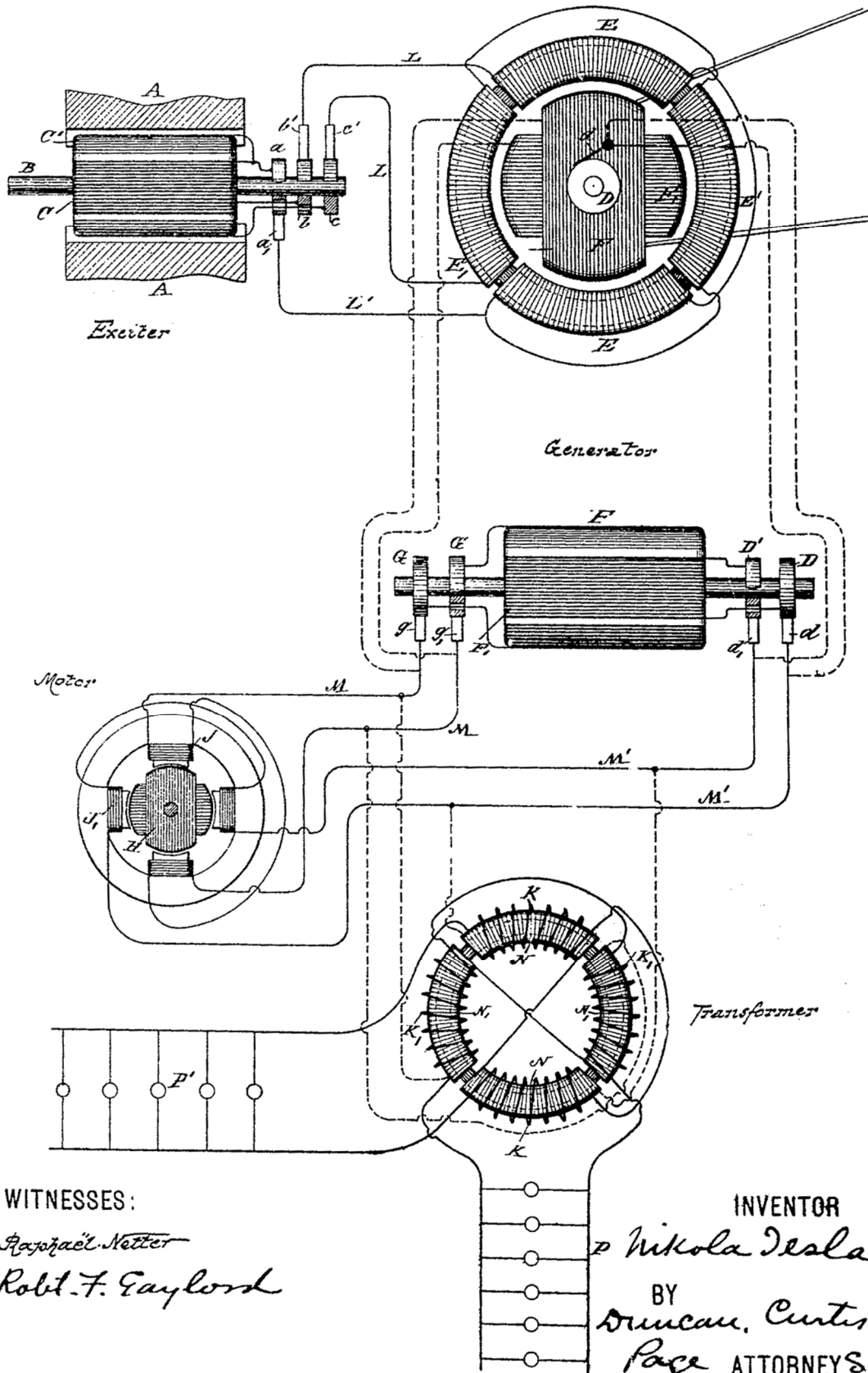
(No Model.)

N. TESLA.

DYNAMO ELECTRIC MACHINE.

No. 390,721.

Patented Oct. 9, 1888.



WITNESSES:

Rapahael Netter

Robt. F. Gaylord

INVENTOR

Nikola Tesla

BY

Duncan, Curtis & Page ATTORNEYS.

REGULATOR FOR ALTERNATE- CURRENT MOTORS.

用于交流电动机的调节器

NIKOLA TESLA, OF NEW YORK, N. Y., ASSIGNOR TO THE TESLA ELECTRIC
COMPANY, OF SAME PLACE.

纽约州纽约市的尼古拉·特斯拉，将专利转让给纽约市的特斯拉电气公司。

SPECIFICATION forming part of Letters Patent No. 390,820 dated October 9, 1888.

Application filed April 24, 1888. Serial No. 271,682. (No model.)

该说明书形成了颁发于 1888 年 10 月 9 日编号为 390,820 的专利证书的一部分。

申请于 1889 年 4 月 24 日提交。序列号为 271,682。(没有模型)

To all whom it may concern:

致所有相关人士:

Be it known that I, NIKOLA TESLA, a subject of the Emperor of Austria, from Smiljan, Lika, border country of Austria-Hungary, now residing in New York, in the county and State of New York, have invented certain new and useful Improvements in Regulators for Alternating-Current Motors, of which the following is a specification, reference being had to the drawings accompanying and forming a part of the same.

众所周知，我、尼古拉·特斯拉、一位奥匈帝国的臣民，来自奥匈帝国边境地区的利卡县的史密里安村，现在居住在纽约州纽约郡纽约市，在用于交流电动机的调节器方面已经发明了某种新的和有用的改进，以下是该发明一个说明书，必须参考随附的图纸，它已形成该说明书的一部分。

My invention is an improvement in systems for the electric transmission of power; and it consists in a means of regulating the speed and power of the motor or motors. The system for use with which the invention is more particularly designed is one in which the motors, or what may be in certain cases their equivalents—the electrical transformers—have two or more independent energizing-circuits, which, receiving current from corresponding sources, act to set up a progressive movement or shifting of the magnetic poles of the motors; but the invention is also applicable to other purposes, as will hereinafter appear. I employ the regulator for the purpose of varying the speed of these motors.

我的发明是对电力传输系统的一个改进；并且它包括调节这样的—个或多个电动机的速度和功率的装置。更具体地设计用于本发明的系统是—这样一种系统，其中电动机，或在某些情况下可以是它们的等效物——电力变压器——具有两个或多个独立的励磁电路，它们从相应的电源接收电流，用于建立电动机磁极的渐进转移或移动；但是本发明也适用于其他目的，这将在下文中出现。我使用调节器是为了改变这些电动机的速度。

The regulator proper consists of a form of converter or transformer with one element capable of movement with respect to the other, whereby the inductive relations may be altered, either manually or automatically, for the purpose of varying the strength of the induced current. I prefer to construct this device in such manner that the induced or secondary element may be movable with respect to the other; and the improvement, so far as relates merely to the construction of the device itself, consists, essentially, in the combination, with two opposite magnetic poles, of an armature wound with an insulated coil and mounted on a shaft, whereby it may be turned to the desired extent within the field produced by the poles.

调节器本身由一种转换器或变压器组成，其中一个组件能够相对于另一个组件移动，从而可以手动或自动的方式改变感应关系，来改变感应电流的强度。我倾向于以这样的方式构造该装置，即感应组件或次级组件可以相对于另一个组件移动；并且该改进仅仅涉及装置本身的结构，本质上包括由一个电枢和两个相反磁极构成的组合，该电枢被缠绕有一个绝缘线圈并被安装在一个轴上，因此它可以在由磁极产生的磁场内转动到预期的程度。

The normal position of the core of the secondary element is that in which it most completely closes the magnetic circuit between the poles of the primary element, and in this position its coil is in its most effective position for the inductive action upon it of the primary coils; but by turning the movable core to either side the induced currents delivered by its coil become weaker until, by a movement of the said core and coil through ninety degrees, there will be no current delivered.

次级组件的铁芯所处的正常位置是它最完全闭合初级组件的不同磁极之间的磁路的位置，并且在这个位置，它的线圈处于初级线圈对它的感应作用的最有效位置；但是通过将可移动芯转动到任一侧，由其线圈传送的感应电流变弱，直到所述铁芯和线圈移动通过 90 度，将没有电流传送。

The construction of this device, broadly, I do not claim as of my invention; but this, together with the manner of applying and using the same, which forms the subject of my invention, I will now explain by reference to the accompanying drawings.

这种装置的结构，大体上说，我不要求作为我的发明；但是这与应用它和使用它的方式一起形成了我的发明的主题，我现在将参考附图进行解释。

Figure 1 is a view in side elevation of the regulator. Fig. 2 is a broken section on line x x of Fig. 1. Fig. 3 is a diagram illustrating the preferred manner of applying the regulator to ordinary forms of motors, and Fig. 4 is a similar diagram illustrating the application of the device to my improved alternating-current motors.

图 1 是调节器的侧视图。图 2 是沿图 1 中 x x 线剖开的截面图。图 3 是说明将调节器应用于普通形式的电动机的首选方式的示意图，图 4 是说明将该装置应用于我的改进后的交流电动机的类似示意图。

The regulator may be constructed in many ways to secure the desired result; but in the best form of which I am now aware it is shown in Figs. 1 and 2.

调节器可以以多种方式构造，以确保想要的结果；但是在图 1 和图 2 中展示了我现在知道的最佳形式。

A represents a frame of iron, and I would here state that the plan which is now invariably followed of dividing up all iron cores which are subjected to the influence of alternating currents should be adopted in the construction of this device.

A 代表一个铁的框架，我在这里声明，现在一直遵循的分割所有受到交流电影响的铁芯的方案应该在这个设备的结构中被采用。

B B are the cores of the inducing or primary coils C C, said cores being integral with or bolted to the frame A in any well-known way.

B B 是施感线圈或初级线圈 C C 的铁芯，所述铁芯以任何众所周知的方式与框架 A 形成一体或用螺栓固定到框架 A 上。

D is a shaft mounted in the side-bars, D', and on which is secured a sectional iron core, E, wound with an induced or secondary coil, F, the convolutions of which are parallel with the axis of the shaft. The ends of the core are rounded off, so as to fit closely in the space between the two poles and permit the core E to be turned. A handle, G, secured to the projecting end of the shaft D, is provided for this purpose.

D 是安装在边条 D' 上的轴，在轴 D 上固定有一个分段的铁芯 E，其上缠绕有感应线圈或次级线圈 F，线圈的匝圈与轴的轴线平行。铁芯的端部被磨圆，以便紧密配合在两个磁极之间的空间中，并允许铁芯 E 能够转动。为此目的，提供了一个手柄 G，它被固定在轴 D 的突出端。

Any means may be employed for maintaining the core and secondary coil in any given position to which it is turned by the handle.

可以采用任何手段来将铁芯和次级线圈保持在通过手柄旋转到的任何给定位置。

The operation or effect of the device will be understood by reference to the diagrams illustrating the manner of its application.

通过参考说明其应用方式的示意图，将理解该装置的操作或效果。

In Fig. 3, let H represent an ordinary alternating-current generator, the field-magnets of which are excited by a suitable source of current, I. Let J designate an ordinary form of electro-magnetic motor provided with an armature, K, commutator L, and field-magnets M. It is well known that such a motor, if its field-magnets' cores be divided up into insulated sections, may be practically operated by an alternating current; but in using my regulator with such a motor I include one element of the motor only—say the armature-coils—in the main-circuit of the generator, making the connections through the brushes and the commutator in the usual way. I also include one of the elements of the regulator—say the stationary coils—in the same circuit, and in the circuit with the secondary or movable coil of

the regulator I connect up the field-coils of the motor. I prefer to use flexible conductors to make the connections from the secondary coil of the regulator, as I thereby avoid the use of sliding contacts or rings without interfering with the requisite movement of the core E.

在图 3 中，让 H 表示一个普通的交流发电机，它的场磁体由一个合适的电流源 I 进行励磁。让 J 表示一种普通形式的电磁电动机，它具有一个电枢 K、一个换向器 L 和场磁铁 M。众所周知，这样的电动机，如果它的场磁体的铁芯被分割成被绝缘的分段，实际上该电动机可以通过一个交流电来运行；但在使用我的调节器来调节电动机时，我只在发电机的主电路中包含这种电动机的一个组件——比如电枢线圈，以通常的方式通过电刷和换向器进行连接。我还在同一电路中包含该调节器的一个组件——比如静态线圈——并且在具有调节器的次级或可移动线圈的电路中，我连接了电动机的磁场线圈。我更喜欢使用软导体（软导线）来从调节器的次级线圈进行连接，因为这样可以避免使用滑动触点或滑动环，而不会干扰铁芯 E 的必要运动。

If the regulator be in its normal position, or that in which its magnetic circuit is most nearly closed, it delivers its maximum induced current, the phases of which so correspond with those of the primary current that the motor will run as though both field and armature were excited by the main current.

如果调节器处于其正常位置，或其磁路最接近闭合的位置，它将产生最大的感应电流，其相位与初级电流的相位一致，这样电动机将运行，就好像磁场和电枢都由主电流励磁一样。

To vary the speed of the motor to any rate between the minimum and maximum rates, the core E and coils F are turned in either direction to an extent which produces the desired result, for in its normal position the convolutions of coil F embrace the maximum number of lines of force, all of which act with the same effect upon said coil; hence it will deliver its maximum current; but by turning the coil F out of its position of maximum effect the number of lines of force embraced by it is diminished. The inductive effect is therefore impaired, and the current delivered by coil F will continue to diminish in proportion to the angle at which the coil F is turned until, after passing through an angle of ninety degrees, the convolutions of the coil will be at right angles to those of coils C C, and the inductive effect reduced to a minimum.

为了将电动机的速度改变到最小速度和最大速度之间的任何速度，铁芯 E 和线圈 F 在任一方向上转动到产生所需结果的程度，因为在其正常位置，线圈 F 的匝圈包围着最大数量的磁力线，所有磁力线在所述线圈上产生着相同的效果；因此，它将传送它的最大电流；但是通过将线圈 F 转离其最大作用位置，它所包围的磁力线的数量减少了。感应效应因此被削弱，并且由线圈 F 传送的电流将继续与线圈 F 转动的角度成比例地减小，直到在转过 90 度的角度之后，线圈的匝圈将与线圈 C C 的匝圈成直角，并且感应效应减到最小。

Incidentally to certain constructions, other causes may influence the variation in the strength of the induced currents. For example, in the present case it will be observed that by the first movement of coil F a certain portion of its convolutions are carried beyond the line of the direct influence of the lines of force, and that the magnetic path or circuit for said lines is impaired; hence the inductive effect would be reduced. Next, that after moving through a certain angle, which is obviously determined by the relative dimensions of the bobbin or coil F, diagonally-opposite portions of the coil will be simultaneously included in the field, but in such positions that the lines which produce a current-impulse

in one portion of the coil in a certain direction will produce in the diagonally-opposite portion a corresponding impulse in the opposite direction; hence portions of the current will neutralize one another.

顺便说一下，对于某些结构，其他原因可能会影响感应电流强度的变化。例如，在本例中，可以观察到，由于线圈 F 的第一次运动，它的一部分匝圈被带到力线的径直影响线之外，并且用于所述力线的磁路或电路被削弱；因此，感应效应将会减少。其次，在移动经过了某一角度之后，该角度显然由绕线筒或线圈 F 的相对尺寸确定，线圈的对角线相对部分将同时被包含在磁场中，但是在这样的位置，也就是能产生某一方向上的一个电流脉冲的线圈的一个部分，将产生一个相应脉冲，脉冲方向与对角线相对的部分产生的脉冲方向相反；因此，电流的不同部分将会相互抵消。

As before stated, the mechanical construction of the device may be greatly varied; but the essential conditions of the invention will be fulfilled in any apparatus in which the movement of the elements with respect to one another effects the same results by varying the inductive relations of the two elements in a manner similar to that described.

如前所述，该装置的机械结构可以有很大的变化；但是本发明的基本条件将在任何装置中实现，这些装置中的组件的相对于彼此的运动通过类似所描述的方式改变两个组件的感应关系来实现相同的结果。

It may also be stated that the core E is not indispensable to the operation of the regulator; but its presence is obviously beneficial. This regulator, however, has another valuable property in its capability of reversing the motor, for if the coil F be turned through a half-revolution the position of its convolutions relatively to the two coils C C and the lines of force is reversed, and consequently the phases of the current will be reversed. This will produce a rotation of the motor in an opposite direction. This form of regulator is also applied with great advantage to my system of utilizing alternating currents, in which the magnetic poles of the field of a motor are progressively shifted by means of the combined effects upon the field of magnetizing-coils included in independent circuits, through which pass alternating currents in proper order and relations to each other.

也可以说，铁芯 E 对于调节器的操作不是不可缺少的；但它的存在显然是有益的。然而，这种调节器具有另一个有价值的特性，即它能够使电动机反转，因为如果线圈 F 转过半圈，那么它的匝圈相对于两个线圈 C C 的位置和磁力线就会反转，因此电流的相位就会反转。这将使电动机反向旋转。这种形式的调节器在我的利用交流电的系统中也有着很大的优势，在这种系统中一个电动机磁场的磁极是通过作用在被包含在独立电路中的磁化线圈的磁场上的组合效应而被逐渐转移的，通过独立电路以适当的顺序和相互关系来传递交流电。

In illustration, let P represent one of my generators having two independent coils, P' and P'', on the armature, and T a diagram of a motor having two independent energizing-coils or sets of coils, R R'. One of the circuits from the generator, as S' S', includes one set, R' R', of the energizing-coils of the motor, while the other circuit, as S S, includes the primary coils of the regulator. The secondary coil of the regulator includes the other coils, R R, of the motor.

在图中，让 P 代表我的一个发电机，它的电枢上有两个独立的线圈 P' 和 P''，T 代表一个有两

个独立励磁线圈或线圈组 RR' 的电动机。来自发电机的一个电路，如 $S'S'$ ，包含一组电动机的励磁线圈 $R'R'$ ，而另一个电路，如 SS ，包含调节器的初级线圈。调节器的次级线圈包含电动机的其他线圈 RR 。

While the secondary coil of the regulator is in its normal position it produces its maximum current, and the maximum rotary effect is imparted to the motor; but this effect will be diminished in proportion to the angle at which the coil F of the regulator is turned. The motor will also be reversed by reversing the position of the coil with reference to the coils CC , and thereby reversing the phases of the current produced by the generator. This changes the direction of the movement of the shifting poles which the armature follows.

当调节器的次级线圈处于其正常位置时，它产生最大电流，并且最大旋转效果被传递给电动机；但是这种影响将与调节器的线圈 F 转动的角度成比例地减小。利用相对于线圈 CC 反转线圈 F 的位置，电动机也将反转，从而反转由发电机产生的电流的相位。这改变了电枢所跟随的转移中磁极的运动方向。

One of the main advantages of this plan of regulation is its economy of power. When the induced coils is generating its maximum current, the maximum amount of energy in the primary coils is absorbed; but as the induced coil is turned from its normal position the self-induction of the primary coils reduces the expenditure of energy and saves power.

这种调节方案的主要优点之一是节省能源。当感应线圈正在产生最大电流时，初级线圈中的最大能量被吸收；但是当感应线圈从其正常位置转动时，初级线圈的自感减少了能量消耗并节省了功率。

It is obvious that in practice either coils CC or coil F may be used as primary or secondary, and it is well understood that their relative proportions may be varied to produce any desired difference or similarity in the inducing and induced currents.

显然，在实践中，线圈 CC 或线圈 F 可以用作初级或次级，并且能很好理解它们的相对比例可以变化，以在施感电流和感应电流中产生任何期望的差异或相似性。

I am aware that it is not new to vary the secondary current of an induction-coil by moving one coil with respect to the other, and thereby varying the inductive relations normally existing between the two. This I do not claim.

我知道，通过移动一个线圈相对于另一个线圈来改变一个感应线圈的次级电流，从而改变两个线圈之间正常存在的感应关系，这并不是什么新鲜事。我不主张这一点。

What I claim is—

我主张的是—

1. The combination, with a motor having independent energizing-circuits, of an alternating-current regulator, consisting, essentially, of inducing and induced coils movable with respect to one another,

whereby the strength of the induced currents may be varied, the induced coils being included in and adapted to supply the current for one of the motor-circuits, as set forth.

1、一个交流电调节器与一个具有独立励磁电路的电动机的组合，基本上包括可相对于彼此移动的施感线圈和感应线圈，由此感应电流的强度可以变化，该感应线圈被包含在电动机的一个电路中并适于为该电路提供电流，如前所述。

2. The combination, with a motor adapted to be run or operated by alternating currents and provided with independent energizing-coils, of a regulator consisting of stationary inducing-coils and an induced coil capable of being rotated, whereby it may be turned to a greater or less angle to the primary coils, or its position with respect thereto reversed, the induced coil or coils being included in and adapted to supply the current for one of the motor-circuits, as set forth.

2、一个调节器与一个电动机的组合，该电动机适于由交流电运行或操作，并配有独立的励磁线圈，该调节器包括静态的施感线圈和一个能够旋转的感应线圈，由此该调节器可以相对于初级线圈旋转更大或更小的角度，或者它的相对于初级线圈的位置反转，该感应线圈被包含在电动机的一个电路中并适于为该电路提供电流，如前所述。

NIKOLA TESLA.

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Witnesses:

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(No Model.)

2 Sheets—Sheet 1.

N. TESLA.

REGULATOR FOR ALTERNATE CURRENT MOTORS.

No. 390,820.

Patented Oct. 9, 1888.

Fig. 2

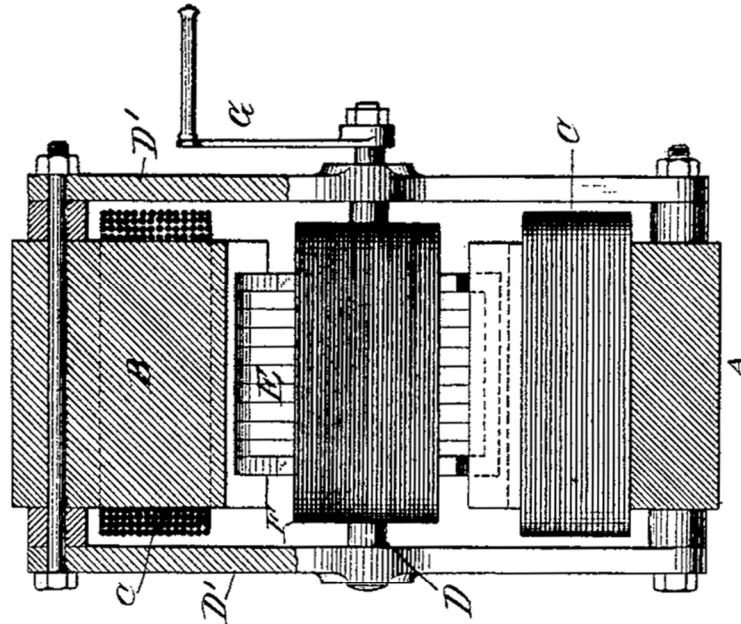
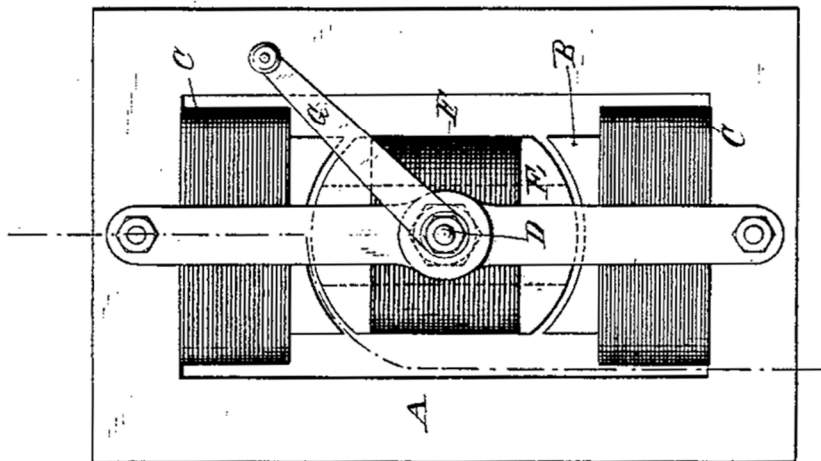


Fig. 1



WITNESSES:

Rapjael Nessler.
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INVENTOR.

Nikola Tesla.
BY
Duncan, Carter & Page.
ATTORNEYS,

N. TESLA.

REGULATOR FOR ALTERNATE CURRENT MOTORS.

No. 390,820.

Patented Oct. 9, 1888.

Fig. 3

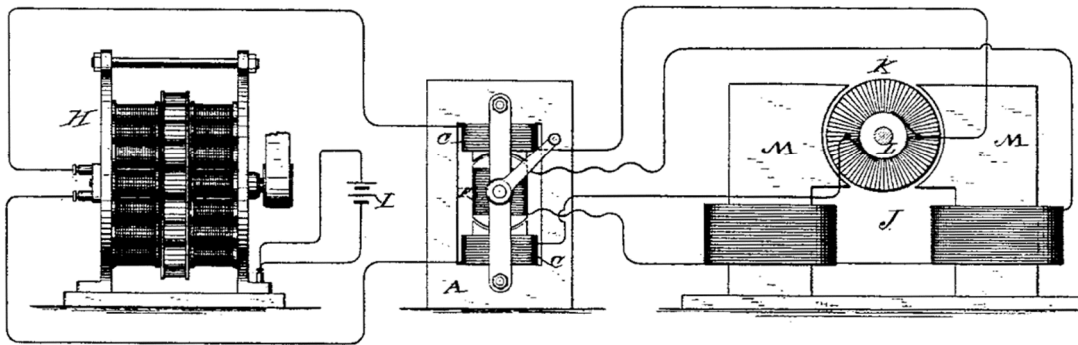
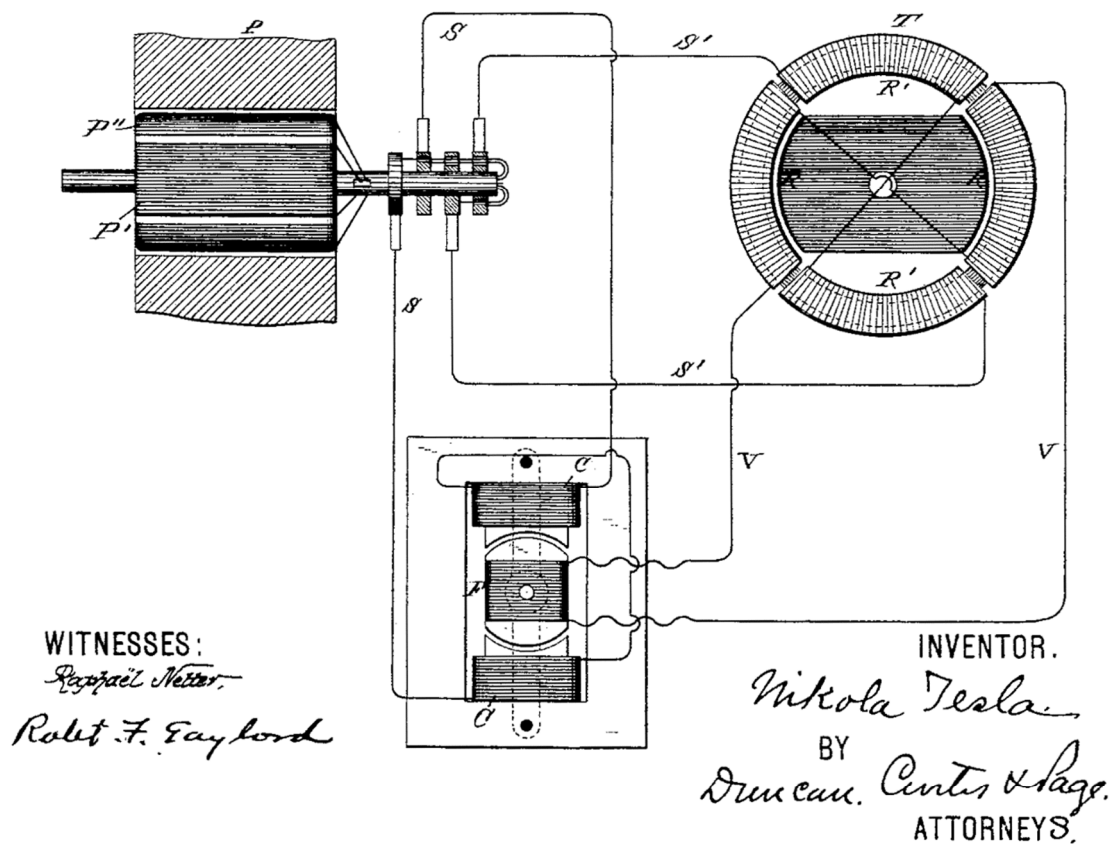


Fig. 4



METHOD OF OPERATING ELECTRO- MAGNETIC MOTORS.

运行电磁电动机的方法

SPECIFICATION forming part of Letters Patent No. 401,520, dated April 16, 1889.

Application filed February 18, 1889. Serial No. 300,220. (No model.)

该说明书形成了颁发于 1889 年 4 月 16 日编号为 401,520 的专利证书的一部分。

申请于 1889 年 2 月 18 日提交。序列号为 300,220。(没有模型)

To all whom it may concern:

致所有相关人士:

Be it known that I, NIKOLA TESLA a subject of the Emperor of Austria, from Smiljan, Lika, border country of Austria-Hungary, and residing at New York, in the county and State of New York, have invented certain new and useful Improvements in Methods of Operating Electro-Magnetic Motors, of which the following is a specification, reference being had to the drawings accompanying and forming a part of the same.

众所周知，我、尼古拉·特斯拉，来自奥匈帝国边境地区的利卡县的史密里安村，居住在纽约州纽约郡纽约市，在运行电磁电动机的方法方面已经发明了一些新的有用的改进，以下是该发明一个说明书，必须参考随附的图纸，它已形成了该说明书的一部分。

As is well known, certain form of alternating-current machines have the property, when connected in circuit with an alternating-current generator, of running as a motor in synchronism therewith; but, while the alternating current will run the motor after it has attained a rate of speed synchronous with that of the generator, it will not start it. Hence, in all instances heretofore where these “synchronizing-motors,” as they are termed, have been run some means have been adopted to bring the motors up to synchronism with the generator, or approximately so, before the alternating current of the generator is applied to drive them. In some instances mechanical appliances have been utilized for this purpose. In others special and complicated forms of motor have been constructed. I have discovered a much more simple method or plan of operating synchronizing-motors, which requires practically no other apparatus than the motor itself. In other words, by a certain change in the circuit-connections of the motor I convert it a will from a double-circuit motor, or such as I have described in prior patents and applications, and which will start under the action of an alternating current into a synchronizing-motor, or one which will be run by the generator only when it has reached a certain speed of rotation synchronous with that of the generator. In this manner I am enabled to very greatly extend the applications of my system and to secure all the advantages of both forms of alternating-current motor.

众所周知，当某些形式的交流电机与一个交流发电机连接，这些交流电机就具有像一个电动机一样的与交流发电机同步运行的属性。但是，当电动机达到与发电机同步的速度后，交流电将使电动机运转，但不会启动电动机。因此，迄今为止，在所有这些被称为“同步电

动机”的情况下，我已经采用了一些方法能在发电机的交流电被用来驱动电动机之前，将电动机带到与发电机同步或者近似同步。在某些情况下，机械设备已被用于这一目的。在其他情况下，已经建造了特殊而复杂的发动机。我发现了一个更简单的运行同步电动机的方法或方案，该方法在实际上除了电动机之外不需要其他设备。换句话说，通过电动机的电路连接中的某种改变，我将它从一个双电路电动机，或者如我在先前的专利和申请中所描述的能在交流电的作用下启动的电动机，转换成一个同步电动机，或者只有当它达到与发电机同步的某一转速时才由发电机运行的电动机。以这种方式，我能够极大地扩展我的系统的应用，并确保两种形式的交流电动机的所有优势。

The expression “synchronous with that of the generator,” is used herein in its ordinary acceptance—that is to say, a motor is said to synchronize with the generator when it preserves a certain relative speed determined by its number of poles and the number of alternations produced per revolution of the generator. Its actual speed, therefore, may be faster or slower than that of the generator; but it is said to be synchronous so long as it preserves the same relative speed.

“与发电机同步”这一表述在本文中以其通常的含义使用，也就是说，当电动机保持在由它的磁极数和发电机每转所产生的交流次数所确定的某一相对速度时，电动机被认为与发电机同步。因此，它的实际速度可以比发电机的速度快或慢；但只要保持相同的相对速度，就称之为同步。

In carrying out my invention I construct a motor which has a strong tendency to synchronism with the generator. The construction which I prefer for this is that in which the armature is provided with polar projections. The field-magnets are wound with two sets of coils, the terminals of which are connected to a switch mechanism, by means of which the line-current may be carried directly through the said coils or indirectly through paths by which its phases are modified. To start such a motor, the switch is turned onto a set of contacts which includes in one motor-circuit a dead resistance, in the other an inductive resistance, and, the two circuits being in derivation, it is obvious that the difference in phase of the current in such circuits will set up a rotation of the motor. When the speed of the motor has thus been brought to the desired rate, the switch is shifted to throw the main current directly through the motor-circuits, and although the currents in both circuits will now be of the same phase the motor will continue to revolve, becoming a true synchronous motor. To secure greater efficiency, I wind the armature or its polar projections with coils closed on themselves. There are various modifications and important features of this method or plan; but the main principle of the invention will be understood from the foregoing.

在实施我的发明时，我构建了一台电动机，它具有与发电机同步的强烈趋势。为此，我更喜欢的结构是电枢具有极性突起。场磁体被缠绕有两套线圈，线圈的终端连接到开关机械装置，通过该机械装置，线路电流可以直接通过所述线圈承载，或者间接地通过改变其相位的路径承载。为了启动这样的一个电动机，开关被接通到一组触点上，该组触点在一个电动机电路包括一个吸收电阻，在另一个电路包括一个电感电阻，并且，这两个电路是间接的（两个组件不是直接连接，而是通过线圈连接），很明显，在这种电路中电流的相位差将使电动机旋转。当电动机的速度因此达到期望的速率时，开关被切换以使主电流直接通过电动机电路，尽管两个电路中的电流现在将具有相同的相位，但电动机将继续旋转，成为真正的同步电动机。为了确保更高的效率，我用自身闭合的线圈来缠绕电枢或其磁极。该方法或方案有各种修改和重要特征；但是本发明的主要原理将从上述的内容中得到理解。

In the drawings, to which I now refer, I have illustrated by the diagrams the general features of construction and operation which distinguish my invention, Figure 1 being drawn to illustrate the details of the plan above set forth, and Figs. 2 and 3 modifications of the same.

在我现在参考的附图中，我已经通过图示说明了区别我的发明的结构和操作的一般特征，图 1 被绘制来说明上述计划的细节，图 2 和图 3 是其修改。

Referring to Fig. 1, let A designate the field-magnets of a motor, the polar projections of which are wound with coils B C included in independent circuits, and D the armature with polar projections wound with coils E closed upon themselves, the motor in these respects being similar in construction to those described in my patent, No. 382,279, dated May 1, 1888, but having, by reason of the polar projections on the armature-core or other similar and well-known features, the properties of a synchronizing-motor.

参考图 1，让 A 表示一个电动机的场磁体，其极性突出部分缠绕有被包含在独立电路中的线圈 B C，用 D 表示电枢，其极性突出部分缠绕有自身闭合的线圈 E，该电动机在这些方面与在 1888 年 5 月 1 日授予我的第 382,279 号专利中描述的电动机在结构上相似，但是由于电枢铁芯上的极性突出部分或其他相似且众所周知的特征，该电动机具有同步电动机的特性。

L L' represent the conductors of a line from an alternating-current generator G.

L L'代表来自交流发电机 G 的一条线路。

Near the motor is placed a switch the action of which is that of the one shown in the drawings, which is constructed as follows: F F' are two conducting plates or arms, pivoted at their ends and connected by an insulating cross-bar, H, so as to be shifted in parallelism. In the path of the bars F F' is the contact 2, which forms one terminal of the circuit through coils C, and the contact 4, which is one terminal of the circuit through coils B. The opposite end of the wire of coils C is connected to the wire L or bar F', and the corresponding end of coils B is connected to wire L' and bar F; hence if the bars be shifted so as to bear on contacts 2 and 4 both sets of coils B C will be included in the circuit L L' in multiple arc or derivation. In the path of the levers F F' are two other contact-terminals, 1 and 3. The contact 1 is connected to contact 2 through an artificial resistance, I, and contact 3 with contact 4 through a self-induction coil, J, so that when the switch-levers are shifted onto the points 1 and 3 the circuits of coils B and C will be connected in multiple arc or derivation to the circuit L L', and will include the resistance and self-induction coil, respectively. A third position of the switch is that in which the levers F and F' are shifted out of contact with both sets of points. In this case the motor is entirely out of circuit.

在电动机附近放置了一个开关，其作用与附图中所示的开关相同，其结构如下：F F' 是两个导电的板或臂，在其端部枢接，并由绝缘横杆 H 连接，以便能平行移动。在条 F F' 的路径中是触点 2，它形成通过线圈 C 的电路的一个终端；触点 4，它形成通过线圈 B 的电路的一个终端。线圈 C 的导线的相对两端连接到导线 L 或条 F'，线圈 B 的相应端连接到导线 L' 和条 F 上；因此，如果条被移动来倚靠触点 2 和 4，两组线圈 B C 将被包括在并联或间接连接的电路 L L' 中。在杠杆 F F' 的路径中的是另外两个接触终端 1 和 3。触点 1 通过一个仿真电阻 I 连接到触点 2，触点 3 通过自感线圈 J 连接到触点 4，因此当开关杠杆移动到点 1 和 3 上时，线圈 B 和 C 的电路将被并联到或间接连接到电路 L L'，并且将分别包含电阻和自感线圈。

开关的第三个位置是杠杆 F 和 F' 被移出与两组点接触的位置。在这种情况下,电动机完全脱离电路。

The purpose and manner of operating the motor by these devices are as follows: The normal position of the switch, the motor being out of circuit, is off the contact-points. Assuming the generator to be running, and that it is desired to start the motor, the switch is shifted until its levers rest upon points 1 and 3. The two motor-circuits are thus connected with the generator-circuit; but by reason of the presence of the resistance I in one and the self-induction coil J in the other the coincidence of the phases of the current is disturbed sufficiently to produce a progression of the poles, which starts the motor in rotation. When the speed of the motor has run up to synchronism with the generator, or approximately so, the switch is shifted over onto the points 2 and 4, thus cutting out the coils I and J, so that the currents in both circuits have the same phase; but the motor now runs as a synchronous motor, which is well known to be a very desirable and efficient means of converting and transmitting power.

这些装置操作电动机的目的和方式如下:当电动机不在电路中时,开关的正常位置不在触点上。假设发电机正在运行,并且希望启动电动机,开关被切换直到其杠杆停留在点 1 和 3 上。两个电动机电路因此与发电机电路连接;但是由于在一个电路中存在电阻 I,在另一个电路中存在自感线圈 J,不同电流相位的同时性被充分扰动,从而产生磁极的移动,这启动了电动机的旋转。当电动机的速度已经上升到与发电机同步,或接近同步时,开关切换到点 2 和 4 上,从而切断线圈 I 和 J,使得两个电路中的电流具有相同的相位;但是电动机现在作为同步电动机运行,众所周知,这是转换动力和传输动力的非常理想的和有效的方式。

It will be understood that when brought up to speed the motor will run with only one of the circuits B or C connected with the main or generator circuit, or the two circuits may be connected in series. This latter plan is preferable when a current having a high number of alternations per unit of time is employed to drive the motor. In such case the starting of the motor is more difficult and the dead and inductive resistance must take up a considerable proportion of the electro-motive force of the circuits. Generally I so adjust the conditions that the electro-motive force used in each of the motor-circuits is that which is required to operate the motor when its circuits are in series. The plan which I follow in this case is illustrated in Fig. 2. In this diagram the motor has twelve poles and the armature has polar projections D wound with closed coils E. The switch used is of substantially the same construction as that shown in the previous figure. There are, however, five contacts, which I have designated by the figures 5, 6, 7, 8, and 9. The motor-circuits B C, which include alternate field-coils, are connected to the terminals in the following order: One end of circuit C is connected to contact 9 and to contact 5 through a dead resistance, I. One terminal of circuit B is connected to contact 7 and to contact 6 through a self-induction coil, J. The opposite terminals of both circuits are connected to contact 8.

可以理解的是,当达到速度时,电动机将仅使用与主电路或发电机电路连接的电路 B 或 C 中的一个来运行,或者两个电路可以串联连接。当采用每单位时间具有一个高交变次数的电流来驱动电动机时,后一种方案是首选的。在这种情况下,电动机的启动将更加困难,吸收电阻和电感电阻必须占据电路电动势的相当大的比例。总的来说,我这样调整条件,使得在每个电动机电路中使用的电动势是当它的电路串联时运行电动机所需的电动势。我在这种情况下遵循的方案如图 2 所示。在该图中,电动机有 12 个磁极,电枢有极性突起 D,缠绕有闭合线圈 E。所用开关的结构与上图所示的基本相同。然而,有五个接触点,我用数字 5、

6、7、8 和 9 表示。包含交变励磁线圈的电动机电路 BC 按以下顺序连接至终端:电路 C 的一端通过一个吸收电阻 I 连接到触点 9 和触点 5。电路 B 的一端通过自感线圈 J 连接到触点 7 和触点 6。两条电路的相对端都连接到触点 8。

One of the levers, as F, of the switch is made with an extension, f, or otherwise, so as to cover both contacts 5 and 6 when shifted into the position to start the motor. It will be observed that when in this position and with lever F' on contact 8 the current divides between the two circuits B C, which from their difference in electrical character produce a progression of the poles that starts the motor in rotation. When the motor has attained the proper speed, the switch is shifted so that the levers cover the contacts 7 and 9, thereby connecting circuits B and C in series. I have found that by this disposition the motor is maintained in rotation in synchronism with the generator. This principle of operation, which consists in converting by a change of connections or otherwise a double-circuit motor or one operating by a progressive shifting of the poles into an ordinary synchronizing-motor may be carried out in many other ways. For instance, instead of using the switch shown in the previous figures, I may use a temporary ground-circuit between the generator and motor, in order to start the motor, in substantially the manner indicated in Fig. 3. Let G in this figure represent an ordinary alternating-current generator with, say, two poles, M M', and an armature wound with two coils, N N', at right angles and connected in series. The motor has, for example, four poles wound with coils B C, which are connected in series and an armature with polar projections D wound with closed coils E E. From the common joint or union between the two circuits of both the generator and the motor an earth-connection is established, while the terminals or ends of the said circuits are connected to the line. Assuming that the motor is a synchronizing-motor or one that has the capability of running in synchronism with the generator, but not of starting, it may be started by the above-described apparatus by closing the ground-connection from both generator and motor. The system thus becomes one with a two-circuit generator and motor, the ground forming a common return for the currents in the two circuits L and L'. When by this arrangement of circuits the motor is brought to speed, the ground-connection is broken between the motor or generator, or both, and ground, switches P P' being employed for this purpose. The motor then runs as a synchronizing-motor.

开关杠杆之一,如 F 具有延伸部 f 或其它形状,以便在转换到启动马达的位置时覆盖触点 5 和触点 6。可以观察到,当延伸部 f 在这个位置并且杠杆 F' 在触点 8 上时,电流在两个电路 BC 之间分流,这从它们的电特性的差异产生了启动电动机旋转的磁极前进。当电动机达到适当的速度时,开关被切换,使得杠杆覆盖触点 7 和 9,从而串联电路 B 和 C。我发现,通过这种配置,电动机保持与发电机同步旋转。这种运行原理包括通过连接的一个改变或其他方式将一个双电路电动机,或通过逐步转移磁极的方式正在运行的一个电动机,转换成一个普通同步电动机,这种工作原理可以以许多其他方式实现。例如,取代前面附图中所示的开关,我可以使发电机和电动机之间的一个临时接地电路,以便以基本上如图 3 所示的方式启动电动机。设图中的 G 代表一台普通的交流发电机,它有两个磁极 MM', 一个电枢上绕有两个线圈 NN', 这两个线圈成直角并串联。例如,电动机具有四个缠绕有线圈 BC 的磁极,线圈 BC 串联连接,以及一个具有缠绕有闭合线圈 EE 的极性突起 D 的电枢。从发电机和电动机的两个电路之间的公共接头或结合处建立接地连接,同时所述电路的终端或末端连接到线路。假设电动机是一个同步电动机,或者是能够与发电机同步运行但不能启动的一个电动机,它可以由上述装置通过闭合发电机和电动机的接地连接来启动。因此,该系统成为一个具有一个双电路的发电机和电动机的系统,接地形成两个电路 L 和 L' 中的电流的公共回路。当通过这种电路布置使电动机加速时,电动机或发电机与接地之间或两者与接地之

间的连接断开，开关 P P' 用于此目的。然后，电动机作为一个同步电动机运行。

In describing those features which constitute my invention I have omitted illustrations of the appliances used in conjunction with the electrical devices of similar systems—such, for instance, as driving-belts, fixed and loose pulleys for the motor, and the like; but these are matters well understood.

在描述构成我的发明的那些特征时，我已经省略了与类似系统的电气设备结合使用的电器的说明——例如，驱动带、电动机的松紧滑轮，等等；但这些都是众所周知的事情。

In describing my invention by reference to specific constructions I do not wish to be understood as limiting myself to the construction shown; and in explanation of my intent in this respect I would say that I may in such forms of apparatus as I have shown in Figs. 1 and 2 include the dead resistance and self-induction coil in either circuit, or use only a dead resistance or a self-induction coil, as in the various ways shown in my application, No. 293,052, filed December 8, 1888. I may also use any form of switch, whether manual or automatic, that will by its manipulation or operation effect the required change of connections, and in order to secure the necessary difference of phase in the two motor-circuits on starting I may employ any of the known means for this purpose.

在通过参考特定结构来描述我的发明时，我不希望被理解为把我自己局限于所示的结构；在解释我在这方面的意图时，我想说，我可以在图 1 和图 2 所示的这种形式的装置中，在任一电路中包含吸收电阻和自感线圈，或者仅使用一个吸收电阻或一个自感线圈，如我在 1888 年 12 月 8 日提交的第 293,052 号申请中所示的各种方式。我也可以使用任何形式的开关，无论是手动的还是自动的，通过其控制或操作来实现所需的连接变化，为了确保启动时两个电机电路中必要的相位差，我可以采用任何已知的方法来实现这一目的。

I believe that I am the first to operate electro-magnetic motors by alternating currents in any of the ways herein suggested or described—that is to say, by producing a progressive movement or rotation of their poles or points of greatest magnetic attraction by the alternating currents until they have reached a given speed, and then by the same currents producing a simple alternation of their poles, or, in other words, by a change in the order or character of the circuit-connections to convert a motor operating on one principle to one operating on another, for the purpose described.

我相信我是以这里建议或描述的任何方式来使用交流电操作电磁电动机的第一人——也就是说，通过交流电产生其磁极或最大磁引力点的渐进转移或旋转，直到电磁电动机达到一个给定的速度，然后通过相同的电流产生电磁电动机磁极的简单交替，或者换句话说，通过电路连接的顺序或特性的改变，将根据一种原理操作的电动机转换为根据另一种原理操作的电动机，用于所述的目的。

I do not claim herein of itself the method of or apparatus for operating a motor which forms a part of this invention and which involves the principle of varying or modifying the currents passing through the energizing-circuits, so as to produce between such currents a difference of phase, as these matters are described and claimed by me in other applications, but with the object of securing, broadly, the method as a whole which I have herein set forth.

我在此并不主张构成本发明一部分的用于运行一个电动机的方法或设备，该方法或设备包括

可以改变或修改流经励磁电路的电流的原理，以便在这样的电流之间产生一个相位差，因为这些问题由我在其他申请中描述和主张，但是目的是广泛地保护我在此阐述的作为一个整体的方法。

What I claim is—

我主张的是—

1. The method of operating an alternating-current motor herein described by first progressively shifting or rotating its poles or points of greatest attraction and then, when the motor has attained a given speed, alternating the said poles, as described.

1、在此描述的运行一个交流电动机的方法是，首先逐渐转移或旋转其最大吸引的磁极或点，然后，当电动机达到给定速度时，交替所述磁极，如上所述。

2. The method of operating an electro-magnetic motor herein described, which consists in passing through independent energizing-circuits of the motor alternating currents differing in phase and then, when the motor has attained a given speed, alternating currents coinciding in phase, as described.

2、在此描述的运行一个电磁电动机的方法，包括使相位不同的交流电流通过电动机的独立励磁电路，然后当电动机达到给定速度时，使相位一致的交流电流通过，如所描述的。

3. The method of operating an electro-magnetic motor herein described, which consists in starting the motor by passing alternating currents differing in phase through independent energizing-circuits and then, when the motor has attained a given speed, joining the energizing-circuits in series and passing an alternating current through the same.

3、在此描述的运行一个电磁电动机的方法，包括让不同相位的交流电流过独立的励磁电路来启动电动机，然后当电动机达到一个给定速度时，串联这些励磁电路并使一个交流电通过这些励磁电路。

4. The method of operating a synchronizing-motor, which consists in passing an alternating current through independent energizing-circuits of the motor and introducing into such circuits a resistance and self-induction coil, whereby a difference of phase between the currents in the circuits will be obtained, and then, when the speed of the motor synchronizes with that of the generator, withdrawing the resistance and self-induction coil, as set forth.

4、运行一个同步电动机的方法，包括让一个交流电通过电动机的独立励磁电路，并在这样的电路中引入一个电阻和自感线圈，从而获得电路中电流之间的相位差，然后，当电动机的速度与发电机的速度同步时，撤出电阻和自感线圈，如上所述。

NIKOLA TESLA.

尼古拉·特斯拉

Witnesses:

GEO. M. MONRO,

WM. H. LEMON.

见证人:

杰奥·M·门罗、WM·H·莱蒙。

(No Model.)

N. TESLA.

METHOD OF OPERATING ELECTRO MAGNETIC MOTORS.

No. 401,520.

Patented Apr. 16, 1889.

Fig. 1

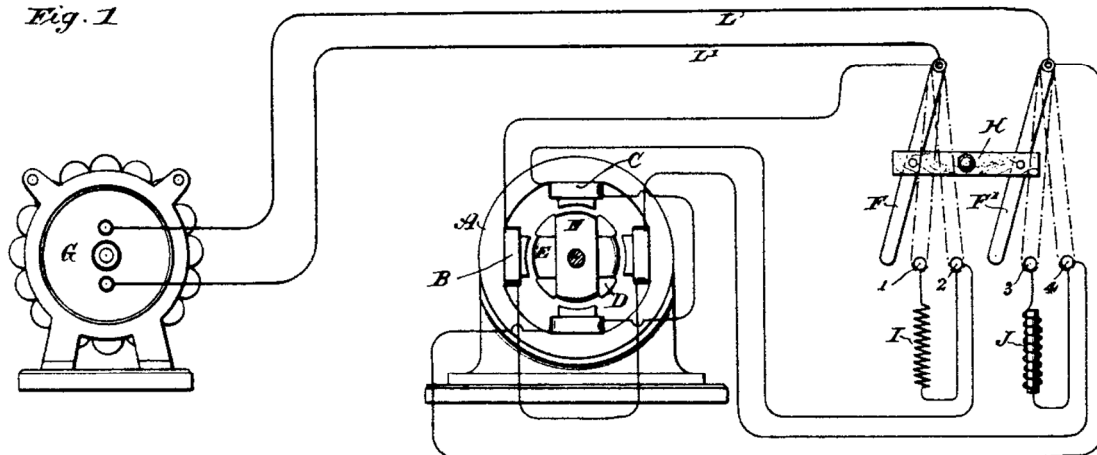


Fig. 2

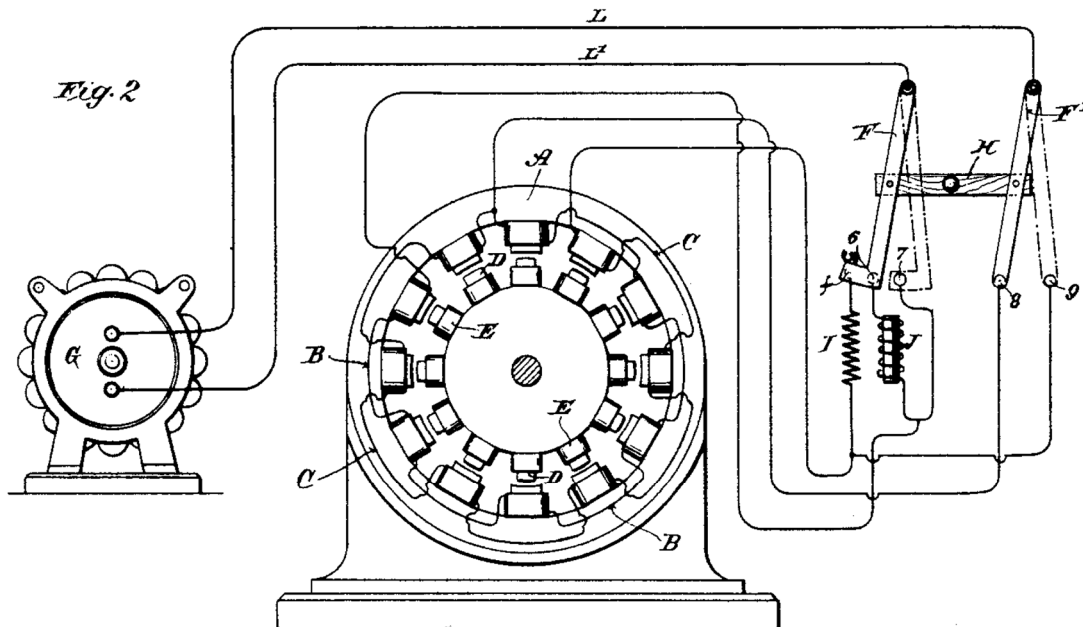
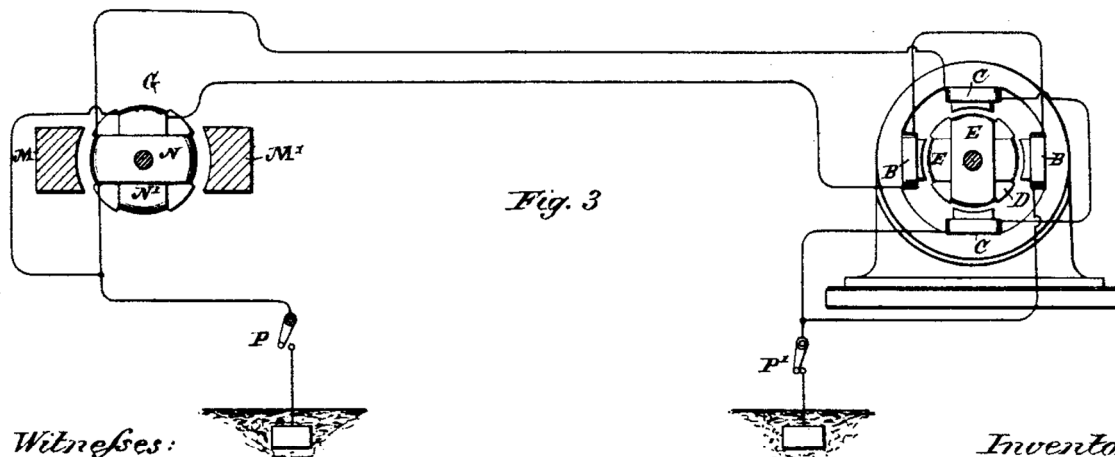


Fig. 3



Witnesses:
Rajahar Nether
Ernest Hopkinson

Inventor:
Nikola Tesla
by
Duncan, Curtis & Page.
Attorneys.

ELECTRO-MAGNETIC MOTOR.

电磁电动机

NIKOLA TESLA, OF NEW YORK, N. Y., ASSIGNOR TO THE TESLA ELECTRIC
COMPANY, OF SAME PLACE.

纽约州纽约市的尼古拉·特斯拉，将专利转让给纽约市的特斯拉电气公司。

SPECIFICATION forming part of Letters Patent No. 405,858, dated June 25, 1889.

Application filed January 8, 1889. Serial No. 295,745. (No model.)

该说明书形成了颁发于 1889 年 6 月 25 日编号为 405,858 的专利证书的一部分。

申请于 1889 年 1 月 8 日提交。序列号为 295,745。(没有模型)

To all whom it may concern:

致所有相关人士:

Be it known that I, NIKOLA TESLA, from Smiljan, Lika, border country of Austria-Hungary, a subject of the Emperor of Austria, residing at New York, in the county and State of New York, have invented certain new and useful Improvements in Electro-Magnetic Motors, of which the following is a specification, reference being had to the drawings accompanying and forming a part of the same.

众所周知，我、尼古拉·特斯拉，来自奥匈帝国边境地区的利卡县的史密里安村，是一位奥匈帝国的臣民，现在居住在纽约州纽约郡纽约市，在电磁电动机方面已经发明了某种新的和有用的改进，以下是该发明一个说明书，必须参考随附的图纸，它已形成该说明书的一部分。

In order to define more clearly the relations which the motor forming the subject of my present application bears to others of the class to which it pertains, I will recapitulate briefly the forms of alternating-current motors invented by me and described more in detail in my prior patents and applications. Of these there are two principal types or forms: first, those containing two or more energizing-circuits through which are caused to pass alternating currents differing from one another in phase to an extent sufficient to produce a continuous progression or shifting of the poles or points of greatest magnetic effect, in obedience to which the movable element of the motor is maintained in rotation; second, those containing poles or parts of different magnetic susceptibility, which under the energizing influence of the same current or two currents coinciding in phase will exhibit differences in their magnetic periods or phases. In the first class of motors the torque is due to the magnetism established in different portions of the motor by currents from the same or from independent sources, and exhibiting time differences in phase. In the second class the torque results from the energizing effects of a current upon parts of the motor which differ in magnetic susceptibility—in other words, parts which respond to the same relative degree to the action of a current, not simultaneously, but after different intervals of time. In my present invention, however, the torque, instead of being solely the result of a time difference in the magnetic periods or phases of the poles or attractive parts to whatever cause due, is produced by an angular displacement of the parts which, though movable with respect to

one another, are magnetized simultaneously, or approximately so, by the same currents. This principle of operation I have embodied practically in a motor in which I obtain the necessary angular displacement between the points of greatest magnetic attraction in the two elements of the motor—the armature and field—by the direction of the lamination of the magnetic cores of said elements, and the best means of accomplishing this result of which I am at present aware I have shown in the accompanying drawings.

为了更清楚地定义构成本申请主题的电动机与其所属类别的其它电动机之间的关系,我将简要地概述由我发明的交流电动机的形式,这种形式已经在我以前的专利和申请中更详细地描述过。其中有两种主要类型或形式:第一种包含了两个或多个励磁电路的电路,通过这些电路产生相位互不相同的交流电,其差异程度足以产生磁极或最大磁效应点的逐渐转移或移动,从而使电动机的可移动组件保持旋转;第二种包含了不同磁化率的磁极或部件,在同一个电流或相位一致的两个电流的励磁影响下,其磁周期或相位将呈现差异。在第一类电动机中,转矩是由于来自同一个电源或独立的(多个)电源的电流在电动机的不同部分建立的磁性,并且表现出相位差。在第二类中,转矩产生于电流对磁化率不同的电动机部件的励磁效应——换句话说,不同的部件对同一个电流的作用的响应相对程度相同,但不是同时响应,而是在不同的时间间隔后响应。然而,在我的本发明中,转矩并不仅仅是由于任何原因引起的磁极或吸引部件的磁周期或相位的时间差的结果,而且是由这些部件的一个角位移产生的,这些部件虽然可相对于彼此移动,但被相同的电流同时或近似同时磁化。我实际上已经在一个电动机中实现这个运行原理,在该电动机中我利用所述组件的磁芯的叠片方向,获得电动机的两个组件(电枢和磁场)中的最大磁引力点之间的必要角位移,以及实现这个结果的最佳手段,我目前知道我已经附图中展示了该结果。

Figure 1 is a side view of the motor with a portion of its armature-core exposed. Fig. 2 is an end or edge view of the same. Fig. 3 is a central cross-section of the same, the armature being shown mainly in elevation.

图 1 是电动机的侧视图,其电枢铁芯的一部分暴露在外。图 2 是电动机的端视图或侧视图。图 3 是电动机的中心横截面,主要以正视图显示了电枢。

Let A A designate two plates built up of thin sections or laminae of soft iron insulated more or less from one another and held together by bolts a or any other suitable means and secured to a base B. The inner faces of these plates contain recesses or grooves in which a coil or coils D are secured obliquely to the direction of the laminations. Within the coils D is a disk E, preferably composed of a spirally-wound iron wire or ribbon or a series of concentric rings and mounted on a shaft F, having bearings in the plates A A. Such a device when acted upon by an alternating current is capable of rotation and constitutes a motor, the operation of which I explain in the following manner: A current or current-impulse traversing the coils D tends to magnetize the cores A A and E, all of which are within the influence of the magnetic field of the coils. The poles thus established would naturally lie in the same line at right angles to the coils D, but in the plates A they are deflected by reason of the direction of the laminations and appear at or near the extremities of said plates. In the disk, however, where these conditions are not present, the poles or points of greatest attraction are on a line at right angles to the plane of the coils; hence there will be a torque established by this angular displacement of the poles or magnetic lines, which starts the disk in rotation, the magnetic lines of the armature and field tending toward a position of parallelism. This rotation is continued and maintained by the reversals of the

current in coils D D, which change alternately the polarity of the field-cores A A. This rotary tendency or effect will be greatly increased by winding the disk with conductors G, closed upon themselves and having a radial direction, whereby the magnetic intensity of the poles of the disk will be greatly increased by the energizing effect of the currents induced in the coils G by the alternating currents in coils D. The plan of winding and the principle of operation have been fully explained in my patent, No. 382,279, of May 1, 1888.

让 A A 表示由软铁薄板或薄片构成的两块板，这些薄板或薄片或多或少相互绝缘，并用螺栓 a 或任何其他合适的工具固定在一起，并固定在底座 B 上。这些板的内表面包含凹槽或沟槽，一个或多个线圈 D 倾斜于叠片的方向固定在槽中。线圈 D 内是一个圆盘 E，最好由一条螺旋缠绕的铁丝或铁带或一系列同心环组成，并安装在轴 F 上，在板 A A 中具有轴承。这种装置在交流电的作用下能够旋转，并构成一个电动机，我以下面的方式解释它的操作：通过线圈 D 的一个电流或电流脉冲倾向于磁化铁芯 A A 和 E，所有这些都在线圈磁场的影响范围内。因此建立的磁极自然地处于与线圈 D 成直角的同一条直线上，但是在板 A 中，它们由于叠片方向的原因而被偏转，并且出现在所述板的末端处或末端附近。然而，在圆盘 E 中，这些条件不存在，最大吸引力的极或点在与线圈平面成直角的直线上；因此，磁极或磁力线的这种角位移会产生一个转矩，使得圆盘开始旋转，电枢和磁场的磁力线趋向一个平行位置。这种旋转是通过线圈 D 中电流的反转来继续和维持的，这种反转交替地改变励磁铁芯 A-A 的极性。这种旋转趋势或效果将通过用导体 G 缠绕的圆盘而大大增加，导体 G 自身闭合并具有一个径向方向，因此，线圈 D 中的交流电在线圈 G 中感应出的电流所产生的励磁效果将大大增强圆盘磁极的磁场强度。我在 1888 年 5 月 1 日申请的专利第 382,279 号中已经充分说明了缠绕方案和工作原理。

The cores of the disk and field may or may not be of different magnetic susceptibility—that is to say, they may both be of the same kind of iron, so as to be magnetized at approximately the same instant by the coils D; or one may be of soft iron and the other of hard, in order that a certain time may elapse between the periods of their magnetization. In either case rotation will be produced; but unless the disk is provided with the closed energizing-coils it is desirable that the above described difference of magnetic susceptibility be utilized to assist in its rotation.

圆盘和磁场的铁芯可以具有不同的磁化率，也可以具有相同的磁化率——也就是说，它们可以都是同一种铁，以便在大约相同的时刻被线圈 D 磁化；或者一个是软铁，另一个是硬铁，以便在它们的磁化周期之间可以经过一定的时间。在任何一种情况下都会产生旋转；但是除非该圆盘配有闭合的励磁线圈，否则最好利用上述磁化率的差异来帮助其旋转。

The cores of the field and armature may be made in various ways, as will be well understood, it being only requisite that the laminations in each be in such direction as to secure the necessary angular displacement of the points of greatest attraction. Moreover, since the disk may be considered as made up of an infinite number of radial arms, it is obvious that what is true of a disk holds, under well-understood conditions, for many other forms of armature, and my invention in this respect is in no sense limited to the specific form of armature shown.

众所周知，磁场和电枢的铁芯可以用各种方式制造，唯一的必要条件是每一个叠片的方向要保证最大吸引点的必要角位移。此外，由于圆盘可以被认为是由无限数量的辐射臂组成，很明显，在众所周知的条件下，盘的真实情况适用于许多其他形式的电枢，并且我的发明在这

方面决不限于所示电枢的特定形式。

It will be understood that the specific ways of carrying out this invention are almost without number, and that, therefore, I do not limit myself to the precise form of motor which I have herein shown.

可以理解的是，实施本发明的具体方式几乎是数不胜数的，因此，我并不局限于我在此所展示的电动机的精确形式。

I believe that I am the first to produce rotation of an armature, at least such as could be utilized for any general or practicable purposes, by means of an alternating current passing through a single coil or several coils acting as one, and which have a direct magnetizing effect upon the cores of both armature and field, and this I claim in its broadest sense.

我相信我是利用流经单个线圈或作为一个线圈的几个线圈的交流电来产生电枢旋转的第一人，至少可以用于任何一般或可行的目的，并且这些线圈有作用在电枢铁芯和磁场铁芯上的直接磁化效果，并且我在最广泛的意义上主张这一点

I further believe that I am the first to impart directly, by means of an alternating current, magnetism to the cores of the two elements of a motor, and by the direction of the lamination of one or both of the same to produce an angular displacement of the poles or lines of magnetic force of the cores, respectively.

我进一步相信我是利用交流电直接将磁力赋予给一个电动机的两个组件的铁芯的第一人，并通过其中一个或两个组件的叠片方向来分别产生各组件铁芯的磁极或者磁力线的一个角位移。

What I therefore claim is—

因此，我的主张是—

1. An electro-magnetic motor consisting of a field-magnet, a rotary armature, and a single coil adapted to be connected to a source of alternating currents and to impart magnetism to both the armature and the field-magnet with angular displacement of the maximum points, as set forth.

1、一种电磁电动机，由一个场磁体、一个旋转电枢和一个单线圈组成，该电动机适于连接到交流电源，并利用最大点的角位移将磁性传递给电枢和场磁体，如上所述。

2. In an electro-magnetic motor, the combination, with a coil adapted to be connected with a source of alternating currents, of a field-magnet and rotary armature the cores of which are in such relation to the coil as to be energized thereby and subdivided or laminated in such manner as to produce an angular displacement of their poles or the magnetic lines therein, as set forth.

2、在一种电磁电动机中，存在着一个组合，包括一个场磁体、一个旋转电枢和一个线圈，该线圈适于与交流电源连接，该场磁体和旋转电枢的铁芯与线圈的关系使得铁芯被励磁，并且被细分或被叠片，使得它们的磁极或其中的磁力线产生角位移，如前所述。

3. In an electro-magnetic motor, the combination, with a coil adapted to be connected with a source of alternating currents, of field-magnets with laminations lying obliquely to the plane of said coil and a circular or disk armature mounted to rotate between the field-magnets, both field and armature being under the magnetizing influence of the coil, as set forth.

3、在一种电磁电动机中，存在着一个组合，包括一个适于与交流电源连接的线圈；一个场磁体，具有相对于所述线圈平面倾斜的叠片；被安装在场磁体之间旋转的圆形或盘形电枢，磁场和电枢都受到线圈的磁化影响，如上所述。

4. In an electro-magnetic motor, the combination, with a coil adapted to be connected with a source of alternating currents, of field-magnets with laminations lying obliquely to the plane of the coil and a circular or disk armature with spiral or concentric laminations mounted between the field-magnets, both field and armature being under the magnetizing influence of the coil, as set forth.

4、在一种电磁电动机中，存在着一个组合，包括一个适于与交流电源连接的线圈、一个场磁体，具有相对于所述线圈平面倾斜的叠片；具有被安装在场磁体之间的螺旋或同心叠片的圆形或盘形电枢，磁场和电枢都受到线圈的磁化影响，如上所述。

5. In an electro-magnetic motor, the combination, with a coil adapted to be connected to a source of alternating currents, of a field-magnet and a rotary armature with closed coils thereon, both the field and the armature being under the magnetizing influence of said coil and laminated to produce an angular displacement of the poles of the two cores.

5、在一种电磁电动机中，存在着一个组合，包括一个适于与交流电源连接的线圈；一个场磁体；一个自身缠绕有闭合线圈的旋转电枢，磁场和电枢都受到所述线圈的磁化影响，并由叠片制成以产生两个铁芯的磁极的角位移。

NIKOLA TESLA.
尼古拉·特斯拉

Witnesses:

EDWARD T. EVANS,
GEORGE N. MONRO.

见证人:

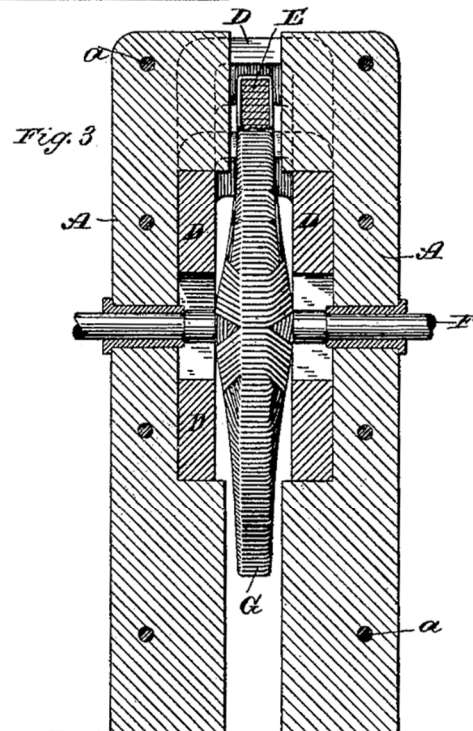
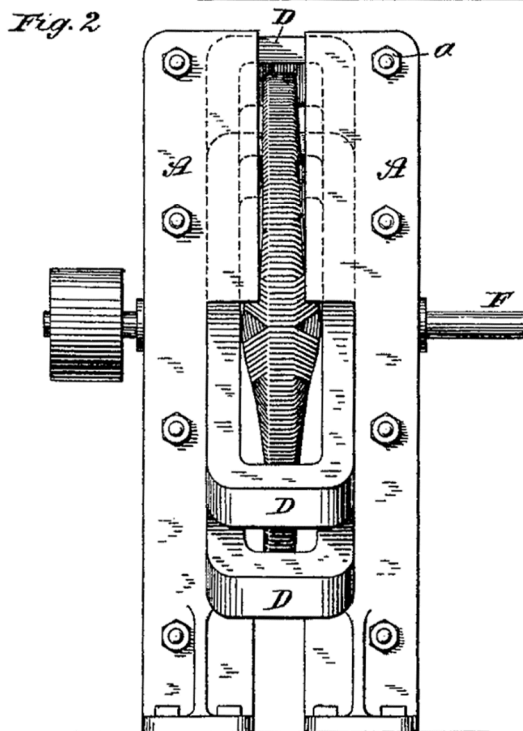
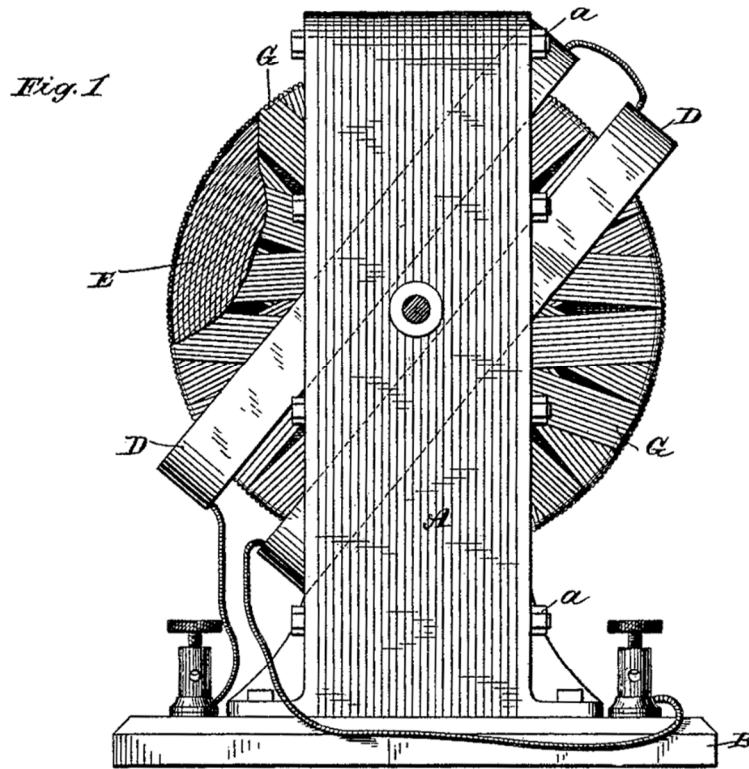
爱德华·T·埃文斯、乔治·门罗。

(No Model.)

N. TESLA.
ELECTRO MAGNETIC MOTOR.

No. 405,858.

Patented June 25, 1889.



WITNESSES:

Raphael Netter
Robt. F. Gaylord

INVENTOR

Nikola Tesla
BY
Duncan, Curtis & Page
ATTORNEYS.

METHOD OF ELECTRICAL POWER TRANSMISSION.

电力传输的方法

NIKOLA TESLA, OF NEW YORK, N. Y., ASSIGNOR TO THE TESLA ELECTRIC
COMPANY, OF SAME PLACE.

纽约州纽约市的尼古拉·特斯拉将专利权转让给纽约市的特斯拉电气公司

SPECIFICATION forming part of Letters Patent No. 405,859, dated June 25, 1889.

Application filed March 14, 1889. Serial No. 303,251. (No model.)

该说明书形成了颁发于 1889 年 6 月 25 日编号为 405,859 的专利证书的一部分。

申请于 1889 年 3 月 14 日提交。序列号为 303,251。(没有模型)

To all whom it may concern:

致所有相关人士:

Be it known that I, NIKOLA TESLA, a subject of the Emperor of Austria, from Smiljan, Lika, border country of Austria-Hungary, residing at New York, in the county and State of New York, have invented certain new and useful Improvements in Methods of Electrical Power Transmission, of which the following is a specification, reference being had to the drawing accompanying and forming a part of the same.

众所周知，我、尼古拉·特斯拉、一位奥匈帝国的臣民，来自奥匈帝国边境地区的利卡县的史密里安村，现在居住在纽约州纽约郡纽约市，在电力传输的方法方面已经发明了某种新的和有用的改进，以下是该发明一个说明书，必须参考随附的图纸，它已形成该说明书的一部分。

This application is for a specific method of transmitting power electrically, shown and described in, and covered broadly by the claims of, an application filed by me February 18, 1889, No. 300,220.

本申请是关于一种电力传输的特定方法，该方法在由我于 1889 年 2 月 18 日提交的第 300,220 号申请中展示和描述，并通过主张要求广泛涵盖。

As is well known, certain forms of alternating-current machines have the property, when connected in circuit with an alternating-current generator, of running as a motor in synchronism therewith; but, while the alternating current will run the motor after it has attained a rate of speed synchronous with that of the generator, it will not start it; hence, in all instances heretofore where these “synchronizing motors,” as they are termed, have been run, some means have been employed to bring the motors up to synchronism with the generator, or approximately so, before the alternating current of the generator is applied to drive them. In some instances mechanical appliances have been utilized for this purpose. In

others special and complicated forms of motor have been constructed.

众所周知，当某些形式的交流电动机在电路中与一个交流发电机连接时，该电动机具有作为与该发电机同步运行的电动机特性，但是，当交流电流达到与发电机同步的速度后，它将使电动机运转，但不会启动电动机，因此，迄今为止，在这些被称为“同步电动机”的电动机已经运行的所有情况下，在发电机的交流电被用来驱动电动机之前，已经采用了一些手段来使电动机与发电机同步，或者大致同步。在某些情况下，机械设备已被用于这一目的。在其他一些情况下，已经建造了特殊且复杂的电动机。

My present invention is an improvement in methods of operating these motors and involves a new and improved plan of bringing the motor up to the proper rate of speed, that it may be run in synchronism with the generator.

我的发明是对运行这些电动机的方法的改进，并且涉及一种使电动机达到适当速度的新颖的和改进的方案，以便它可以与发电机同步运行。

The expression “synchronism with the generator” is used herein in its ordinary acceptance—that is to say, a motor is said to synchronize with the generator when it preserves a certain relative speed determined by its number of poles and the number of alternations produced per revolution of the generator. Its actual speed, therefore, may be faster or slower than that of the generator, but it is said to be synchronous so long as it preserves the same relative speed.

“与发电机同步”这一表述在本文中是以其通常的含义使用的，也就是说，当电动机保持着由它的极数和发电机每转产生的交流次数所确定的某一相对速度时，就称电动机与发电机同步。因此，它的实际速度可以快于或慢于发电机的速度，但只要它保持相同的相对速度，就可以说它是同步的。

In carrying out my present invention I construct a generator with two coils or sets of coils and a motor with corresponding energizing coils or sets of coils. By means of two line-wires one terminal of each generator-coil or set of coils is connected to one terminal of its corresponding motor-coil or set of coils, while the opposite terminals of the generator-coils are joined together and likewise those of the motor.

在实施我的发明时，我构造了具有两个线圈或两个线圈组的一个发电机和具有相应励磁线圈或线圈组的一个电动机。通过两条线路导线，发电机的每个线圈或线圈组的一个终端连接到其对应的电动机线圈或线圈组的一个终端，而发电机线圈的相反终端连接在一起，电动机的相反终端也是如此。

To start the motor I establish temporarily an electrical connection between the points of connection between the coils in the generator and those in the motor, so that the system becomes an ordinary double-circuit system identical with that described in my patent, No. 390,413, of October 2, 1888, except that the generator and motor are constructed in any well-known way with a strong tendency to synchronize. When by this plan of connection the motor has attained the desired speed, the earth-connection is severed, by which means the system becomes an ordinary single-circuit synchronizing system.

为了启动电动机，我在发电机线圈和电动机线圈之间的不同连接点之间临时建立了电连接，这样该系统就变成了一个普通的双电路系统，该系统除了发电机和电动机以任何众所周知的具有强烈的同步倾向的方式进行构造之外，它与在 1888 年 10 月 2 日授予我的第 390,413 号专利中描述的系统相同。当使用这种连接方案，在电动机达到预定速度时，接地连接被切断，这意味着系统成为一个普通的单电路同步系统。

In the drawing I have illustrated this method by a diagram.

在图中，我用一张示意图说明了这种方法。

Let G represent an ordinary alternating-current generator having four field-poles A, permanently or artificially magnetized, and an armature wound with two coils C connected together in series.

让 G 代表一台普通的交流发电机，它有四个永久的或人工磁化的磁极 A，还有一个缠绕有两个串联线圈 C 的电枢。

Let M represent an alternating-current motor with, say, four poles D, the coils on which are connected in pairs and the pairs connected in series. The motor-armature should have polar projections and closed coils E.

让 M 代表一台交流电动机，它有四个磁极 D，其上的线圈成对连接，并且线圈对串联连接。电动机电枢应该有极性突起和闭合线圈 E。

From the common joint or union between the two coils or sets of coils of both the generator and motor an earth-connection F is established, while the terminals or ends of the said coil or circuits which they form are connected to the line-conductors H H.

从发电机和电动机的两个线圈或两组线圈之间的公共接头或连接点处建立接地连接 F，而它们形成的所述线圈或电路的终端或末端连接到线路导体 H H。

Assuming that the motor is a synchronizing motor, or one that has the capability of running in synchronism with the generator, but not of starting, it may be started by the above-described plan by closing the ground-connection from both generator and motor. The system thus becomes one with a two-circuit generator and motor, the ground forming a common return for the currents in the two wires H H. When by this arrangement of circuits the motor is brought to speed, the ground-connection is broken between the generator or motor or both and ground, switches K K being employed for this purpose. The motor then runs as a synchronizing motor.

假设该电动机是一个同步电动机，或者具有与发电机同步运行的能力，但没有启动能力，则可以利用上述方案，通过闭合发电机和电动机的接地连接来启动电动机。这样，这个系统就变成了具有一个双电路发电机和电动机的一个系统，接地线形成了两条导线 H H 中电流的公共回路。当通过这种电路布置使电动机加速时，发电机或电动机或两者与接地之间的连接断开，开关 K K 用于此目的。然后，电动机作为一个同步电动机运行。

This system is capable of various useful applications which it is not necessary to describe in detail; but

it will be enough to say that the convertibility of the system from double circuit to single circuit is a feature in itself of great value and utility.

该系统能够进行各种有用的应用，无需赘述；但它将足以说明系统从双电路到单电路的可转换性本身就是一个具有巨大价值和实用性的特征。

I do not wish to be understood as confining myself to the precise arrangement or order of connections herein set forth, as these may be obviously varied in many respects.

我不希望被理解为将我自己限制在这里阐述的精确布置或连接顺序，因为这些在许多方面可以是明显不同的。

What I claim is—

我主张的是—

1. The method of operating synchronizing motors herein described, which consists in electrically connecting intermediate points of the inducing-circuit of the generator and the energizing-circuit of the motor until the motor has reached a desired speed and then interrupting such connection, as set forth.

1、在此描述的运行同步电动机的方法，在于电连接发电机的感应电路和电动机的励磁电路的中间点，直到电动机达到预期的速度，然后中断这种连接，如上所述。

2. The method herein described of starting or operating synchronizing motors, which consists in electrically connecting intermediate points of the inducing-circuit of the generator and the energizing-circuit of the motor to earth until the motor has reached the desired speed and then interrupting either or both of the ground-connections, as set forth.

2、这里描述的启动或运行同步电动机的方法，在于将发电机的感应电路和电动机的励磁电路的中间点电连接到接地，直到电动机达到预期的速度，然后中断接地连接中的一个或两个，如上所述。

NIKOLA TESLA.

尼古拉·特斯拉

Witnesses:

EDWARD T. EVANS,

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见证人:

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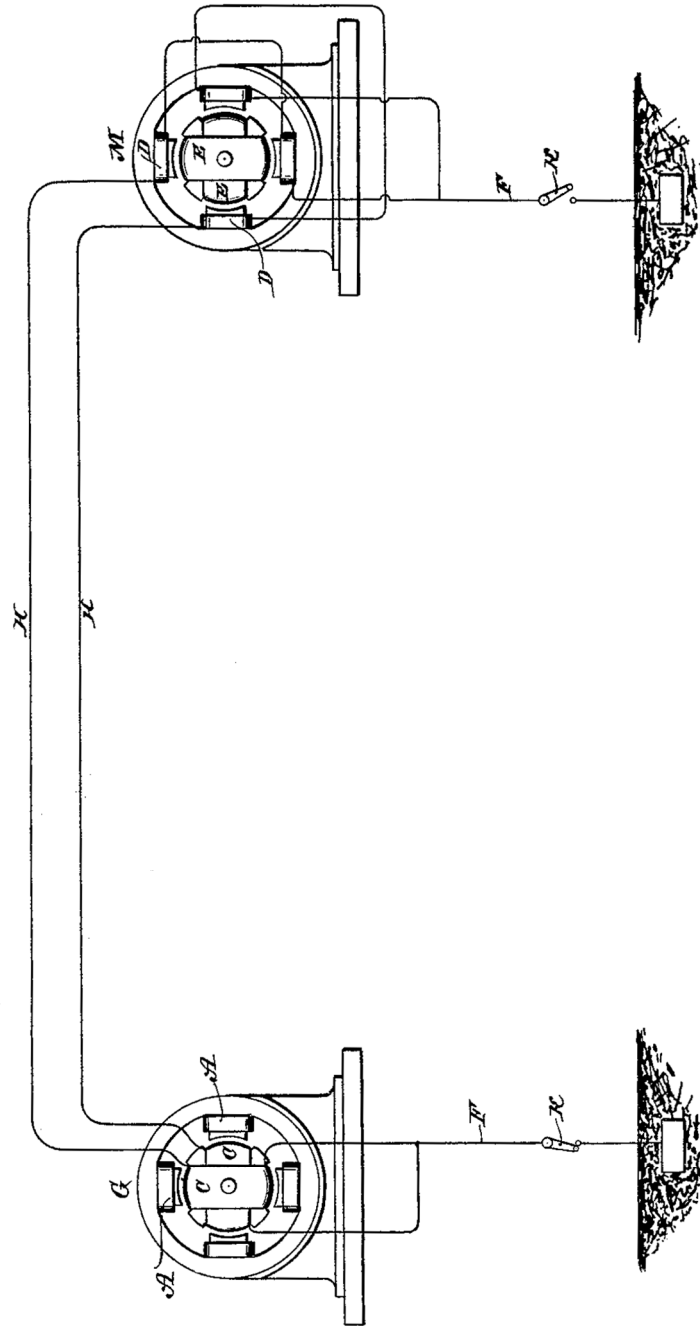
(No Model.)

N. TESLA.

METHOD OF ELECTRICAL POWER TRANSMISSION.

No. 405,859.

Patented June 25, 1889.



Witnesses:
Raphael Netter
Robt. F. Gaylord

Inventor
Nikola Tesla
By
Duncan, Curtis & Page.
Attorney.

DYNAMO-ELECTRIC MACHINE.

电动发电机

SPECIFICATION forming part of Letters Patent No. 406,968, dated July 16, 1889.

Application filed March 23, 1889. Serial No. 304,498. (No model.)

该说明书形成了颁发于 1889 年 7 月 16 日编号为 406,968 的专利证书的一部分。

申请于 1889 年 3 月 23 日提交。序列号为 304,498。(没有模型)

To all whom it may concern:

致所有相关人士:

Be it known that I, NIKOLA TESLA from Smiljan, Lika, border country of Austria-Hungary, a subject of the Emperor of Austria, and a resident of New York, in the county and State of New York, have invented certain new and useful Improvements in Dynamo or Magneto Electric Machines, of which the following is a specification, reference being had to the accompanying drawings.

众所周知，我、尼古拉·特斯拉，来自奥匈帝国边境地区的利卡县的史密里安村，一位纽约州纽约郡纽约市的居民，在发电机或磁电机方面已经发明了某些新的和有用的改进，以下是该发明一个说明书，必须参考随附的图纸。

This invention relates to that class of electrical generators known as “unipolar,” in which a disk or cylindrical conductor is mounted between magnetic poles adapted to produce an approximately-uniform field. In the first-named or disk armature machines the currents induced in the rotating conductor flow from the center to periphery, or conversely, according to the direction of rotation or the lines of force as determined by the signs of the magnetic poles, and these currents are taken off usually by connections or brushes applied to the disk at points on its periphery and near its center.

本发明涉及一类称为“单极”的发电机，其中的圆盘或圆柱形导体被安装在磁极之间，适于产生近似一致的场。在第一种或圆盘式电枢电机中，旋转导体中被感应产生的电流从中心流向外周，或者相反，根据旋转方向或由磁极符号确定的磁力线，这些电流通常通过应用到圆盘上的连接或电刷在圆盘外周和中心附近的点上被取走。

In the case of the cylindrical armature-machine the currents developed in the cylinder are taken off by brushes applied to the sides of the cylinder at its ends.

在圆柱形电枢电动机的情况下，在圆柱中产生的电流被应用到圆柱端部的电刷取走。

In order to develop economically an electro-motive force available for practicable purposes, it is necessary either to rotate the conductor at a very high rate of speed or to use a disk of large diameter or cylinder of great length; but in either case it becomes difficult to secure and maintain a good electrical connection between the collecting-brushes and the conductor, owing to the high peripheral speed.

为了经济地产生电动势并用于实用的目的，必须以一个很高的速度旋转导体，或者使用大直径的圆盘或大长度的圆柱；但是在任何一种情况下，由于高的圆周速度，在集电刷和导体之间确保和维持良好的电连接变得困难。

It has been proposed to couple two or more disks together in series with the object of obtaining a higher electro-motive force; but with the connections heretofore used and using other conditions of speed and dimension of disk necessary to securing good practicable results this difficulty is still felt to be a serious obstacle to the use of this kind of generator. These objections I have sought to avoid; and for this purpose I construct a machine with two fields, each having a rotary conductor mounted between its poles, but the same principle is involved in the case of both forms of machine above described, and as I prefer to use the disk form I shall confine the description herein to that machine. The disks are formed with flanges, after the manner of pulleys, and are connected together by flexible conducting bands or belts.

已经提出将两个或更多个圆盘串联在一起，目的是获得更高的电动势；但是，对于迄今为止所使用的连接，以及使用为了确保良好的实际效果所必需的圆盘的速度和尺寸的其他条件，这种困难仍然被认为是使用这种发电机的严重障碍。我一直试图避免这些缺陷；为此目的，我构造了一种具有两个场的机器，每个场具有安装在它的磁极之间的旋转导体，但是在上述两种机器形式的情况下涉及了相同的原理，并且由于我更喜欢使用圆盘形式，所以我将这里的描述仅限于此种机器。圆盘以滑轮的方式形成，并具有凸缘，并通过柔性导电带连接在一起。

I prefer to construct the machine in such manner that the direction of magnetism or order of the poles in one field of force is opposite to that in the other, so that rotation of the disks in the same direction develops a current in one from center to circumference and in the other from circumference to center. Contacts applied therefore to the shafts upon which the disks are mounted form the terminals of a circuit the electro-motive force in which is the sum of the electro-motive forces of the two disks.

我更喜欢以这样的方式构造机器，在一个力场中磁性的方向或磁极的顺序与在另一个力场中的相反，所以圆盘在相同方向上的旋转在一个力场中产生一个从中心到外周的电流，在另一个力场中产生一个从外周到中心的电流。施加到安装了圆盘的轴的不同触点形成了一个电路的不同终端，该电路的电动势是两个圆盘的电动势之和。

I would call attention to the obvious fact that if the direction of magnetism in both fields be the same the same result as above will be obtained by driving the disks in opposite directions and crossing the connecting-belts. In this way the difficulty of securing and maintaining good contact with the peripheries of the disks is avoided and a cheap and durable machine made which is useful for many purposes—such as for an exciter for alternating-current generators, for a motor, and for any other purpose for which dynamo-machines are used.

我想提请注意一个显而易见的事实是，如果两个磁场中的磁性方向相同，通过以相反的方向驱动圆盘并交叉连接导电带，将获得与上述相同的结果。以这种方式，在确保和维持与盘外周的良好接触时存在的困难得到避免，并且制造了便宜且耐用的机器，它可用于多种目的，比如用于交流发电机的励磁机、用于电动机以及用于使用发电机的任何其他目的。

The specific construction of the machine which I have just generally described I have illustrated in the accompanying drawings, in which—

我刚刚概括描述的机器的具体结构已经在附图中展示出，其中—

Figure 1 is a side view, partly in section, of my improved machine. Fig. 2 is a vertical section of the same at right angles to the shafts.

图 1 是我的改进机器的侧视图，部分是截面的。图 2 是与轴成直角的垂直截面图。

In order to form a frame with two fields of force, I cast a support A with two pole-pieces B B' integral with it. To this I join by bolts E a casting D, with two similar and corresponding pole-pieces C C'. The pole-pieces B B' are wound or connected to produce a field of force of given polarity, and the pole-pieces C C' are wound or connected to produce a field of opposite polarity. The driving-shafts F G pass through the poles and are journaled in insulating-bearings in the casting A D, as shown.

为了形成一个有两个力场的框架，我铸造了一个具有两个磁极 B B' 的支撑件 A。我用螺栓 E 将铸件 D 连接到支撑件 A 上，铸件 D 具有两个相似且对应的极靴 C C'。极靴 B B' 被缠绕或被连接以产生一个给定极性的力场，极靴 C C' 被缠绕或被连接以产生相反极性的力场。驱动轴 F G 穿过磁极，轴颈安装在铸件 A D 中的被绝缘的轴承中，如图所示。

H K are the disks or generating-conductors. They are composed of copper, brass, or iron and are keyed or secured to their respective shafts. They are provided with broad peripheral flanges J. It is of course obvious that the disks may be insulated from their shafts, if so desired. A flexible metallic belt L is passed over the flanges of the two disks, and, if desired, may be used to drive one of the disks. I prefer, however, to use this belt merely as a conductor, and for this purpose may use sheet steel, copper, or other suitable metal. Each shaft is provided with a driving-pulley M, by which power is imparted from a counter-shaft.

H K 是圆盘或发电导体。它们由铜、黄铜或铁制成，并被锁在或者被固定在各自的轴上。它们配有宽的外周凸缘 J。显然，如果需要的话，圆盘可以与它们的轴绝缘。柔性金属带 L 经过两个圆盘的凸缘，如果需要，可以用来驱动其中一个圆盘。然而，我更喜欢使用这个带仅仅作为导体，为此目的可以使用钢板、铜或其他合适的金属。每个轴都配有一个驱动轮 M，通过该驱动轮 M 从一个副轴传递动力。

N N are the terminals. For sake of clearness they are shown as provided with springs P, that bear upon the ends of the shafts. This machine, if self-exciting, would have copper bands around its poles, or conductors of any kind—such as the wires shown in the drawings—may be used.

N N 是终端。为了清楚起见，它们被展示为配有弹簧 P，弹簧 P 倚靠在轴的端部。如果这台机器是自励磁的，它的磁极周围会有铜带，或者可以使用任何种类的导体，比如图中所示的导线。

I do not limit my invention to the special construction herein shown. For example, it is not necessary that the parts be constructed in one machine or that the materials and proportions herein given be

strictly followed. Furthermore, it is evident that the conducting belt or band may be composed of several smaller bands and that the principle of connection herein described may be applied to more than two machines.

我并不将我的发明局限于这里所示的特殊结构。例如，所有的部件不必在一台机器中制造，也不必严格遵循这里给出的材料和比例。此外，很明显，导电带可以由几个更小的带组成，并且这里描述的连接原理可以应用于两个以上的机器。

What I claim is—

我主张的是—

1. An electrical generator consisting of the combination, with two rotary conductors mounted in unipolar fields, of a flexible conductor or belt passing around the peripheries of said conductors, as herein set forth.

1、一种发电机，由安装在单极场中的两个旋转导体、以及围绕所述导体外周的一个柔性导体或带的组合组成，如本文所述。

2. The combination, with two rotary conducting-disks having peripheral flanges and mounted in unipolar fields, of a flexible conducting belt or band passing around the flanges of both disks, as set forth.

2、两个具有外周凸缘并安装在单极场中的旋转导电盘与围绕这两个盘的凸缘的柔性导电带的组合，如上所述。

3. The combination of independent sets of field-magnets adapted to maintain unipolar fields, conducting-disks mounted to rotate in said fields, independent driving mechanism for each disk, and a flexible conducting belt or band passing around the peripheries of the disks, as set forth.

3、适于维持单极场的独立磁体组、安装成在所述场中旋转的导电盘、每个盘的独立驱动机械装置、以及围绕圆盘外周的柔性导电带的组合，如上所述。

NIKOLA TESLA.

尼古拉·特斯拉

Witnesses:

PARKER W. PAGE,

ROBT. F. GAYLORD.

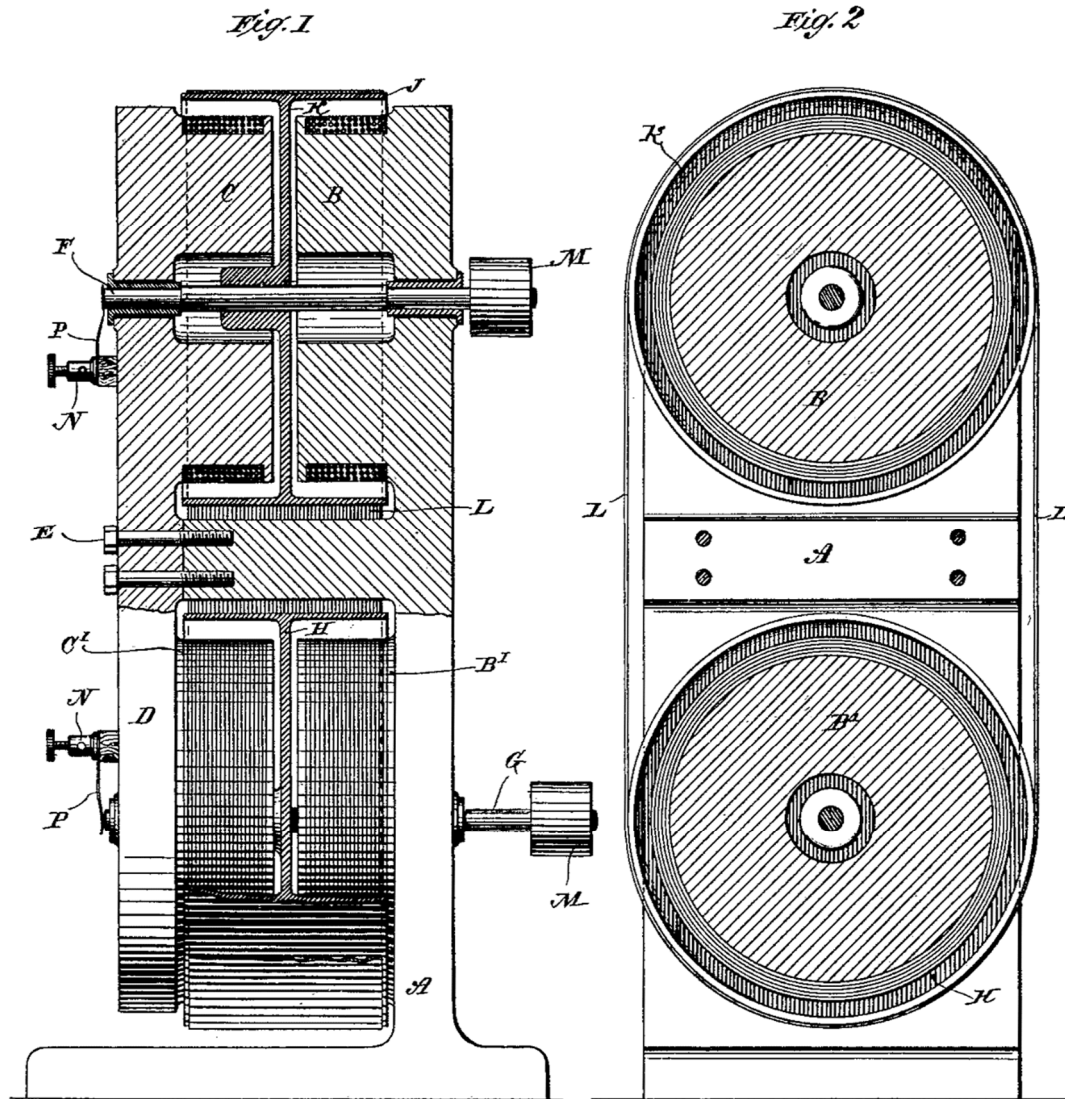
见证人：帕克·W·佩奇、罗伯特·F·盖洛德。

(No Model.)

N. TESLA.
DYNAMO ELECTRIC MACHINE.

No. 406,968.

Patented July 16, 1889.



Witnesses:
Robt. F. Gaylord
Ernest Hopkinson

Inventor
Nikola Tesla
by
Duncan, Curtis & Sage.
Attorneys.

METHOD OF OBTAINING DIRECT FROM ALTERNATING CURRENTS.

从交流电获得直流电的方法

NIKOLA TESLA, OF NEW YORK, N. Y., ASSIGNOR OF TWO-THIRDS TO ALFRED S. BROWN, OF SAME PLACE, AND CHARLES F. PECK, OF ENGLEWOOD, NEW JERSEY

纽约州纽约市的尼古拉·特斯拉，将三分之二的专利权转让给纽约市的
阿尔弗雷德·S·布朗和新泽西州恩格尔伍德市的查尔斯·F·佩克

SPECIFICATION forming part of Letters Patent No. 413,353, dated October 22, 1889.

Application filed June 12, 1889. Serial No. 314,069. (No model.)

该说明书形成了颁发于 1889 年 10 月 22 日编号为 413,353 的专利证书的一部分。

申请于 1889 年 6 月 12 日提交。序列号为 314,069。(没有模型)

To all whom it may concern:

致所有相关人士:

Be it known that I, NIKOLA TESLA, a subject of the Emperor of Austria, from Smiljan, Lika, border country of Austria-Hungary, temporarily residing in New York city, in the State of New York, have invented a certain new and useful Improvement in Methods of Obtaining Direct from Alternating Currents, of which the following is a specification, reference being had to the drawings accompanying and forming a part of the same.

众所周知，我、尼古拉·特斯拉、一位奥匈帝国的臣民，来自奥匈帝国边境地区的利卡县的史密里安村，暂时居住在纽约州纽约郡纽约市，在从交流电获得直流电的方法方面已经发明了某种新的和有用的改进，以下是该发明一个说明书，必须参考随附的图纸，它已形成该说明书的一部分。

In nearly all the more important industrial applications of electricity the current is produced by dynamo-electric machines driven by power, in the coils of which the currents developed are primarily in reverse directions or alternating; but as very many electrical devices and systems require direct currents, it has been usual to correct the current alternations by means of a commutator, instead of taking them off directly from the generating-coils.

在电的几乎所有更重要的工业应用中，电流是由动力驱动的电动发电机产生的，在其线圈中产生的电流主要是在相反方向上的或是交变的；但是，由于许多电气设备和系统需要直流电流，所以通常用换向器来校正交流电流，而不是直接从发电线圈中取出电流。

The superiority of alternating-current machines in all cases where their currents can be used to advantage renders their employment very desirable, as they may be much more economically

constructed and operated; and the object of this my present invention is to provide means for directing or converting at will at one or more points in a circuit alternating into direct currents.

在交流电机的电流可被用来处于有利优势的所有情况下,交流电机的优越性使其应用非常令人满意,因为它们可以被更经济地构造和运行;并且本发明的目的是提供用于在电路中的一个或多个点随意将交流电引导或转换成直流电的装置。

Stated as broadly as I am able to express it, my invention consists in obtaining direct from alternating currents, or in directing the waves of an alternating current so as to produce direct or substantially direct currents by developing or producing in the branches of a circuit including a source of alternating currents, either permanently or periodically, and by electric, electro-magnetic, or magnetic agencies, manifestations of energy, or what may be termed active resistance of opposite electrical character, whereby the currents or current-waves of opposite sign will be diverted through different circuits, those of one sign passing over one branch and those of opposite sign over another.

尽我所能概括地说,我的发明在于从交流电中获得直流电流,或引导一个交流电的波形,以便利用包含了一个交流电源的一个电路的支路来生产直流电或大体上的直流电,这种直流电或者是永久的,或者是周期性的,并通过电的、电磁体或者磁机制、能量的表现,或者相反电特性的所谓有效电阻的方式来获得,由此相反符号的电流或电流波将通过不同的电路转向,一个符号的电流或电流波通过一个分支,而相反符号的电流或电流波通过另一个分支。

I may consider herein only the case of a circuit divided into two paths, inasmuch as any further subdivision involves merely an extension of the general principle. Selecting, then, any circuit through which is flowing an alternating current, I divide such circuit at any desired point into two branches or paths. In one of these paths I insert some device to create an electro-motive force counter to the waves or impulses of current of one sign and a similar device in the other branch which opposes the waves of opposite sign. Assume, for example, that these devices are batteries, primary or secondary, or continuous-current dynamo-machines. The waves or impulses of opposite direction composing the main current have a natural tendency to divide between the two branches; but by reason of the opposite electrical character or effect of the two branches one will offer an easy passage to a current of a certain direction, while the other will offer a relatively high resistance to the passage of the same current. The result of this disposition is, that the waves of current of one sign will, partly or wholly, pass over one of the paths or branches, while those of the opposite sign pass over the other. There may thus be obtained from an alternating current two or more direct currents without the employment of any commutator such as it has been heretofore regarded as necessary to use. The current in either branch may be used in the same way and for the same purposes as any other direct current—that is, it may be made to charge secondary batteries, energize electro-magnets, or for any other analogous purpose.

我可以在这里只考虑电路分为两条路径的情况,因为任何进一步的细分只涉及一般原则的扩展。然后,选择任何一个有交流电流过的电路,我把这个电路在任意一点分成两个支路或两个路径。在这些路径中的其中一个,我插入某个设备来创建一个电动势来对抗一个符号的电流波或电流脉冲,在另一个分支中插入一个类似的设备来对抗相反符号的电流波。例如,假设这些设备是原电池或蓄电池,或者是恒向电流发电机。组成主电流的相反方向的波或脉冲具有在两个分支之间分开的自然趋势;但是由于两个分支的相反的电特性或效果,一个分支将为某一方向的电流提供容易的通路,而另一个分支将为同一电流的通过提供一个相对高的

电阻。这种布置的结果是，一个符号的电流波将部分或全部通过其中一条路径或分支，而相反符号的电流波通过另一条路径或分支。因此，可以从一个交流电获得两个或更多的直流电，而不需要使用任何换向器，例如迄今为止认为必须使用的换向器。任何一个支路中的电流都可以像任何其他直流电一样以同样的方式用于同样的目的——也就是说，它可以用来给蓄电池充电，给电磁铁通电，或用于任何其他类似的目的。

In the drawings I have illustrated some of the various ways in which I may carry out this invention.

在附图中，我已经说明了我可以实施本发明的一些不同的方式。

The several figures are diagrammatic in character, and will be described in detail in their order.

这几幅图在性质上是示意性的，并且将按照它们的顺序进行详细描述。

Figure 1 represents a plan of directing the alternating currents by means of devices purely electrical in character. Figs. 2, 3, 4, 5, 6, and 7 are diagrams illustrative of other ways of carrying out the invention, which will be hereinafter more particularly described.

图 1 展示了通过纯电气特性的设备来引导交流电的方案。图 2、图 3、图 4、图 5、图 6 和图 7 是实施本发明的其他方式的示意图，这将在下文中更具体地描述。

In Fig. 1, A designates a generator of alternating currents, and B B the main or line circuit therefrom. At any given point in this circuit at or near which it is desired to obtain direct currents I divide the circuit B into two paths or branches C D. In each of these branches I place an electrical generator, which for the present we will assume produces direct or continuous currents. The direction of the current thus produced is opposite in one branch to that of the current in the other branch, or, considering the two branches as forming a closed circuit, the generators E F are connected up in series therein, one generator in each part or half of the circuit. The electro-motive force of the current sources E and F may be equal to or higher or lower than the electro-motive forces in the branches C D or between the points X and Y of the circuit B B. If equal, it is evident that current-waves of one sign will be opposed in one branch and assisted in the other to such an extent that all the waves of one sign will pass over one branch and those of opposite sign over the other. If, on the other hand, the electro-motive force of the sources E F be lower than that between X and Y, the currents in both branches will be alternating, but the waves of one sign will preponderate. One of the generators or sources of current E or F may be dispensed with; but it is preferable to employ both, if they offer an appreciable resistance, as the two branches will be thereby better balanced. The translating or other devices to be acted upon by the current are designated by the letters G, and they are inserted in the branches C D in any desired manner; but in order to better preserve an even balance between the branches due regard should be had to the number and character of the devices, as will be well understood.

在图 1 中，A 表示一个交流发电机，BB 表示来自交流发电机的主电路或线路。在该电路中的任何给定点，在该点或该点附近希望获得直流电流，我将电路 B 分成两个路径或分支 C D。在每个分支中，我放置了一个发电机，目前我们假设它产生直流或恒向电流。这样在一个支路中产生的电流，其方向与在另一个支路中的电流方向相反，或者，把两个支路看作形成一个闭合电路，发电机 EF 在该电路中串联起来，电路的每一部分或每一半中有一个发电

机。电流源 E 和 F 的电动势可以等于或高于或低于支路 CD 中或电路 BB 的点 X 和 Y 之间的电动势。如果相等，很明显，一个符号的电流波将在一个分支中被对抗，而在另一个分支中得到促进，以至于一个符号的所有波将通过一个分支，而相反符号的波通过另一个分支。另一方面，如果源 EF 的电动势低于 X 和 Y 之间的电动势，两个分支中的电流将是交替的，但一个符号的波将占优势。其中一个发电机或电流源 EF 可以摒弃；但是如果它们提供一个可观的电阻，则最好使用两者，因为两个分支将因此更好地平衡。由电流作用的转换或其它装置由字母 G 表示，并且它们以任何所需的方式插入分支 CD 中；但是为了更好地保持分支之间的平衡，应该适当考虑装置的数量和特性，这是很容易理解的。

Figs. 2, 3, 4, and 5 illustrate what may be termed “electro-magnetic” devices for accomplishing a similar result—that is to say, instead of producing directly by a generator an electro-motive force in each branch of the circuit, I may establish a field or fields of force and lead the branches through the same in such manner that an active opposition of opposite effect or direction will be developed therein by the passage or tendency to pass of the alternations of current. In Fig. 2, for example, A is the generator of alternating currents, B B the line-circuit, and C D the branches over which the alternating currents are directed. In each branch I include the secondary of a transformer or induction-coil, which, since they correspond in their functions to the batteries of the previous figure, I have designated by the letters E F. The primaries H H' of the induction-coils or transformers are connected either in parallel or series with a source of direct or continuous currents I, and the number of convolutions is so calculated for the strength of the current from I that the cores J J' will be saturated. The connections are such that the conditions in the two transformers are of opposite character—that is to say, the arrangement is such that a current wave or impulse corresponding in direction with that of the direct current in one primary, as H, is of opposite direction to that in the other primary H'; hence it results that while one secondary offers a resistance or opposition to the passage through it of a wave of one sign the other secondary similarly opposes a wave of opposite sign. In consequence the waves of one sign will, to greater or less extent, pass by way of one branch, while those of opposite sign in like manner pass over the other branch.

图 2、图 3、图 4 和图 5 展示了用于实现类似结果的可被称为“电磁”的装置，也就是说，不是由一个发电机在电路的每个分支中直接产生电动势，我可以建立一个或多个力场并引导分支通过上述力场，以这样的方式，利用交流电的从分支上的通过或通过分支的趋势，相反效应或相反方向的一个有效对抗将在分支中产生。例如，在图 2 中，A 是交流发电机，B B 是线路，CD 是交流电流被引向的支路。在每个分支中，我都包含了一个变压器或感应线圈的次级，因为它们在功能上对应于前图中的电池，我用字母 EF 表示。感应线圈或变压器的初级线圈 HH' 与一个直流电源或一个恒向电流源 I 并联或串联，计算线圈匝数以确定来自 I 的能使铁芯 JJ' 饱和的电流强度。这种连接使得两个变压器中的条件具有相反的特性——也就是说，这种布置使得与一个初级线圈中（如 H）的直流电流方向相对应的一个电流波或脉冲与另一个初级线圈中（如 H'）的电流波或脉冲方向相反；因此，当一个次级对一个符号的波在通过该次级时提供一个阻力或对抗时，另一个次级同样对抗相反符号的波。结果，一个符号的波将或多或少地通过一个分支，而相反符号的波以类似的方式通过另一个分支。

In lieu of saturating the primaries by a source of continuous current, I may include the primaries in the branches C D, respectively, and periodically short-circuit by any suitable mechanical devices—such as an ordinary revolving commutator—their secondaries. It will be understood of course that the rotation and action of the commutator must be in synchronism or in proper accord with the periods of the

alternations in order to secure the desired results. Such a disposition I have represented diagrammatically in Fig. 3. Corresponding to the previous figures, A is the generator of alternating currents, B B the line, and C D the two branches for the direct currents. In branch C are included two primary coils E E', and in branch D are two similar primaries F F'. The corresponding secondaries for these coils and which are on the same subdivided cores J or J' are in circuits the terminals of which connect to opposite segments K K' and L L', respectively, of a commutator. Brushes b b bear upon the commutator and alternately short-circuit the plates K and K' and L and L' through a connection c. It is obvious that either the magnets and commutator or the brushes may revolve.

取代利用一个恒向电流源使初级线圈饱和的做法，我可以将初级线圈分别包含在支路 C 和 D 中，并通过任何合适的机械装置（如普通旋转换向器）周期性地短路它们的次级线圈。当然可以理解的是，换向器的旋转和动作必须与交替的周期同步或适当一致，以确保预期的结果。我在图 3 中以图解方式表示了这种配置。与前面的图相对应，A 是交流发电机，B B 是线路，C D 是用于直流电流的两个分支。在支路 C 中包括两个初级线圈 E E'，在支路 D 中包括两个类似的初级线圈 F F'。这些线圈和它们的相应次级线圈都位于相同的细分铁芯 J 或 J' 上，并且它们都处于电路中，这些电路的终端分别连接到换向器的相对分段 K K' 和 L L' 上。电刷 b b 倚靠在换向器上，通过一个连接 c 交替地使极板 K 和 K' 以及 L 和 L' 短路。很明显，磁体和换向器或者电刷都可以旋转。

The operation will be understood from a consideration of the effects of closing or short-circuiting the secondaries. For example, if at the instant when a given wave of current passes one set of secondaries be short-circuited, nearly all the current flows through the corresponding primaries; but the secondaries of the other branch being open-circuited the self-induction in the primaries is highest, and hence little or no current will pass through that branch. If, as the current alternates, the secondaries of the two branches are alternately short-circuited, the result will be that the currents of one sign pass over one branch and those of the opposite sign over the other. The disadvantages of this arrangement, which would seem to result from the employment of sliding contacts, are in reality very slight, inasmuch as the electro-motive force of the secondaries may be made exceedingly low, so that sparking at the brushes is avoided.

该操作将通过考虑闭合次级或短路次级的效果来理解。例如，如果在一个给定电流波通过的瞬间，一组次级被短路，几乎所有的电流都流过相应的初级；但是另一个支路的次级是都是开路的，初级中的自感是最高的，因此很少或没有电流通过该支路。当电流交替时，如果两个支路的次级线圈被交替地短路，结果将是一个符号的电流越过一个支路，而相反符号的电流越过另一个支路。这种布置的缺点看起来是由于使用滑动触点造成的，但实际上非常微弱，因为次级的电动势可以非常低，从而避免了电刷上的火花。

Fig. 4 is a diagram, partly in section, of another plan of carrying out the invention. The circuit B in this case is divided, as before, and each branch includes the coils of both the field and revolving armatures of two induction devices. The armatures O P are preferably mounted on the same shaft, and are adjusted relatively to one another in such manner that when the self-induction in one branch, as C, is maximum in the other branch D it is minimum. The armatures are rotated in synchronism with the alternations from the source A. The winding or position of the armature-coils is such that a current in a given direction passed through both armatures would establish in one poles similar to those in the adjacent poles of the field and in the other poles unlike the adjacent field-poles, as indicated by n n s s in the

drawings. If the like poles are presented, as shown in circuit D, the condition is that of a closed secondary upon a primary, or the position of least inductive resistance; hence a given alternation of current will pass mainly through D. A half-revolution of the armatures produces an opposite effect, and the succeeding current impulse passes through C. Using this figure as an illustration, it is evident that the fields N M may be permanent magnets or independently excited and the armatures O P driven, as in the present case, so as to produce alternate currents, which will set up alternately impulses of opposite direction in the two branches D C, which in such case would include the armature-circuits and translating devices only.

图 4 是实施本发明的另一个方案的部分截面图。在这种情况下，电路 B 如前所述被分开，每个支路包含两个感应装置的励磁线圈和旋转电枢的线圈。电枢 O P 最好地安装在同一轴上，并且彼此相对的关系要调整得使一个分支 C 中的自感最大时，另一个分支 D 中的自感最小。电枢与来自电源 A 的交流同步旋转。电枢线圈的绕组或位置是这样的，即在给定方向上通过两个电枢的电流在其中一个电枢中建立的磁极与邻近的场磁极相同，而在另一个电枢中建立的磁极与邻近的场磁极相反，这些邻近的场磁极在图中用 n n s s 表示。如果出现相同的极点，如电路 D 所示，条件是一个闭合的次级缠绕在初级上，或最小电感阻抗的位置；因此，一个给定的交变电流将主要流过电路 D。电枢半圈旋转产生一个相反的效果，随后的电流脉冲通过电路 C。使用该图作为说明，很明显，如在当前情况下，为了产生交流电，磁场 N M 可以是永磁体或被独立励磁，并且电枢 O P 被驱动，该交变电流将在两个分支 D C 中交替建立相反方向的脉冲，在这种情况下，分支 D C 将仅包含电枢电路和转换装置。

In Fig. 5 a plan alternative with that shown in Fig. 3 is illustrated. In the previous case illustrated each branch C and D contained one or more primary coils, the secondaries of which were periodically short-circuited in synchronism with alternations of current from the main source A, and for this purpose a commutator was employed. The latter may, however, be dispensed with and an armature with a closed coil substituted.

在图 5 中，展示了图 3 所示的替代方案。在前面说明的情况中，支路 C D 的每一个都包含一个或多个初级线圈，这些线圈的次级线圈与来自主电源 A 的电流的变化同步地周期性地被短路，为此目的，使用了一个换向器。然而，后者可以省去，用具有一个闭合线圈的一个电枢代替。

Referring to Fig. 5, in one of the branches, as C, are two coils M', wound on laminated cores, and in the other branches D are similar coils N'. A subdivided or laminated armature O', carrying a closed coil R', is rotatably supported between the coils M' N', as shown. In the position shown—that is, with the coil R' parallel with the convolutions of the primaries N' M'—practically the whole current will pass through branch D, because the self-induction in coils M' M' is maximum. If, therefore, the armature and coil be rotated at a proper speed relatively to the periods or alternations of the source A, the same results are obtained as in the case of Fig. 3.

参考图 5，在其中一个分支中，如 C，是缠绕在叠片铁芯上的两个线圈 M'，在另一个分支 D 中则是类似的线圈 N'。如图所示，携带一个闭合线圈 R' 的一个细分或层叠电枢 O' 可旋转地被支撑在线圈 M' N' 之间。在所示位置，即线圈 R' 与初级线圈 N' M' 的匝圈平行，实际上整个电流将通过支路 D，因为线圈 N' M' 中的自感处于最大值。因此，如果电枢和线圈相对于电源 A 的周期或交替以适当的速度旋转，获得与图 3 的情况相同的结果。

Fig. 6 is an instance of what may be called in distinction to the others, a “magnetic” means of securing the results arrived at in this invention. V and W are two strong permanent magnets provided with armatures V' W', respectively. The armatures are made of thin laminae of soft iron or steel, and the amount of magnetic metal which they contain is so calculated that they will be fully or nearly saturated by the magnets. Around the armatures are coils E F, contained, respectively, in the circuits C and D. The connections and electrical conditions in this case are similar to those in Fig. 2, except that the current source I of Fig. 2 is dispensed with and the saturation of the core of coils E F obtained from the permanent magnets.

图 6 是可以被称为明显区别于其他情况的一个实例，一种“磁性”装置，用于确保本发明中达到的结果。V 和 W 是两个分别具有电枢 V' W' 的强永磁体。电枢由软铁质或钢质的薄片制成，它们包含的磁性金属的量经过这样的计算，使得它们将完全或接近被磁体的磁力线所饱和。电枢周围是分别被包含在电路 C D 中的线圈 E F。这种情况下，除了图 2 中的电流源 I 被省去，并且线圈 E F 的铁芯的磁饱和从永磁体获得外，图 6 中的连接和电气条件与图 2 中的连接和电气条件类似。

In the illustrations heretofore given I have in each instance shown the two branches or paths containing the translating or induction devices as in derivation one to the other; but this is not always necessary. For example, in Fig. 7, A is an alternating-current generator; B B, the line wires or circuit. At any given point in the circuit I form two paths, as D D', and at another point two paths, as C C'. Either pair or group of paths is similar to the previous dispositions with the electrical source or induction device in one branch only, while the two groups taken together form the obvious equivalent of the cases in which an induction device or generator is included in both branches. In one of the paths, as D, are included the devices to be operated by the current. In the other branch, as D', is an induction device that opposes the current impulses of one direction and directs them through the branch D. So, also, in branch C are translating devices G, and in branch C' an induction device or its equivalent that diverts through C impulses of opposite direction to those diverted by the device in branch D'. I have also shown a special form of induction device for this purpose. J J' are the cores, formed with pole-pieces, upon which are wound the coils M N. Between these pole-pieces are mounted at right angles to one another the magnetic armatures O P, preferably mounted on the same shaft and designed to be rotated in synchronism with the alternations of current. When one of the armatures is in line with the poles or in the position occupied by armature P, the magnetic circuit of the induction device is practically closed; hence there will be the greatest opposition to the passage of a current through coils N N. The alternation will therefore pass by way of branch D. At the same time, the magnetic circuit of the other induction device being broken by the position of the armature O, there will be less opposition to the current in coils M, which will shunt the current from branch C. A reversal of the current being attended by a shifting of the armatures, the opposite effect is produced.

在迄今为止给出的说明中，我在每种情况下都展示了包含有转换装置或感应装置的两个分支或路径，上述装置中的一个与另一个间接连接；但这并不总是必要的。例如，在图 7 中，A 是一个交流发电机；B B 是线路导线或电路。在电路中的任意一点，我形成两条路径，如 D D'，在另一点形成两条路径，如 C C'。任何一对或一组路径都类似于前面仅在一个分支中具有电源或感应装置的配置，而这两条路径组合在一起形成了在两个分支中都包含感应装置或发电机的情况的明显等效物。在其中一个路径中，如 D，包含了由电流运行的设备。在另一个分支中，如 D'，是一个感应装置，它对抗一个方向上的电流脉冲，并引导它们通过分支

D。同样，在分支 C 中是转换装置 G，在分支 C' 中是一个感应装置或该感应装置的等效物，该感应装置通过分支 C 转向的脉冲与由分支 D' 中的装置转向的脉冲在方向上相反。为此目的，我还展示了一种特殊形式的感应装置。J J' 是由极靴形成的铁芯，线圈 M N 缠绕在极靴上。在这些极靴之间，彼此成直角地安装有磁性电枢 O P，最好安装在同一轴上，并设计成与电流的交替同步旋转。当电枢之一与磁极成一直线或处于电枢 P 所占据的位置时，感应装置的磁路实际上是闭合的；因此，一个电流通过线圈 N N 时会遇到最大的阻力。因此，交替将通过分支 D。与此同时，另一个感应装置的磁路被电枢 O 的位置断开，线圈 M 中的电流将受到较小的对抗，这将分流来自支路 C 的电流。电流的一次反转伴随着电枢的一次旋转，会产生相反的效果。

There are many other modifications of the means or methods of carrying out my invention; but I have not deemed it necessary herein to specifically refer to more than those described, as they involve the chief modifications of the plan. In all of these it will be observed that there is developed in one or all of the branches of a circuit from a source of alternating currents an active (as distinguished from a dead) resistance or opposition to the currents of one sign, for the purpose of diverting the currents of that sign through the other or another path, but permitting the currents of opposite sign to pass without substantial opposition.

实施我的发明的措施或方法还有许多其他修改；但我认为这里没有必要特别提及超出所描述的内容，因为它们涉及到方案的主要修改。在所有这些措施或方法中，将会观察到，在来自交流电源的一个电路的一个分支或所有分支中，对于一个符号的电流产生了有效的（区别于无效的）电阻或对抗，以便将该符号的电流通过另一条或另一条路径转向，但允许相反符号的电流在通过时没有实质上的阻力。

Whether the division of the currents or waves of current of opposite sign be effected with absolute precision or not is immaterial to my invention, since it will be sufficient if the waves are only partially diverted or directed, for in such case the preponderating influence in each branch of the circuit of the waves of one sign secures the same practical results in many if not all respects as though the current were direct and continuous.

相反符号的电流或电流波的划分是否以绝对精度实现对我的发明来说是无关紧要的，因为如果波只是部分转向或定向就足够了，因为在这种情况下，一个符号的波的电路的每个分支中的优势影响在许多方面（如果不是所有方面）确保了相同的实际结果，就好像电流是直流和恒向的一样。

An alternating and direct current have been combined so that the waves of one direction or sign were partially or wholly overcome by the direct current; but by this plan only one set of alternations are utilized, whereas by my system the entire current is rendered available. By obvious applications of this discovery I am enabled to produce a self-exciting alternating dynamo, or to operate direct-current meters on alternating-current circuit, or to run various devices—such as arc-lamps—by direct currents in the same circuit with incandescent lamps or other devices run by alternating currents.

一个交流电和一个直流电结合在一起，使得一个方向或一个符号的波被直流电部分地或全部地克服；但是通过这个方案，仅利用了一组交替，而通过我的系统，整个电流都是可用的。利用这一发现的明显应用，我能够生产一个自励磁交流发电机，或在交流电路上操作直流电

表，或运行各种设备——例如利用相同电路中的直流电运行弧光灯，这些电路具有白炽灯或其他由交流电运行的设备。

It will be observed that if an intermittent counter or opposing force be developed in the branches of the circuit and of higher electromotive force than that of the generator an alternating current will result in each branch, with the waves of one sign preponderating, while a constantly or uniformly acting opposition in the branches of higher electro-motive force than the generator would produce a pulsating current, which conditions would be under some circumstance the equivalent to those I have previously described.

将观察到，如果在电路的分支中产生一个间歇的对抗或相反的力，并且电动势比发电机的电动势高，则在每个分支中将产生一个交流电流，其中一种符号的波占优势，而在电动势比发电机高的分支中，一个恒向或均匀的反作用将产生一个脉动电流，这种情况在某些情况下将等同于我先前描述的情况。

What I claim as my invention is—

我主张我的发明是—

1. The method herein set forth of obtaining direct from alternating currents, which consists in developing or producing in one branch of a circuit from an alternating-current source an active resistance to the current impulses of one direction, whereby the said currents or waves of current will be diverted or directed through another branch.

1、这里提出的从交流电获得直流电的方法，包括在源自交流电源的电路的一个支路中产生或生产对一个方向的电流脉冲的有效电阻，由此所述电流或电流波将被转向或引导通过另一个支路。

2. The method of obtaining direct from alternating currents, which consists in dividing the path of an alternating current into branches, and developing in one of said branches, either permanently or periodically, an electrical force or active resistance counter to or opposing the currents or current-waves of one sign, and in the other branch a force counter to or opposing the currents or current-waves of opposite sign, as set forth.

2、从交流电获得直流电的方法，包括将一个交流电的路径分成不同支路，并且在所述支路之一中永久地或周期性地产生与一种符号的电流或电流波对抗或相反的排斥力或有效电阻，并且在另一支路中产生与相反符号的电流或电流波对抗或相反的力，如上所述。

3. The method of obtaining direct from alternating currents, which consists in dividing the path of an alternating current into branches, establishing fields of force and leading the said branches through the said fields of force in such relation to the lines of force therein that the impulses of current of one direction will be opposed in one branch and those of opposite direction in the other, as set forth.

3、从交流电获得直流电的方法，包括将交流电的路径分成不同支路，建立力场，并引导所述支路通过所述力场，使所述支路与所述力场的磁力线的关系使得一个方向的电流脉冲在一

个支路中是被对抗，而相反方向的电流脉冲在另一个支路中是被对抗，如上所述。

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N. TESLA.

METHOD OF OBTAINING DIRECT FROM ALTERNATING CURRENTS.

No. 413,353.

Patented Oct. 22, 1889.

Fig. 1

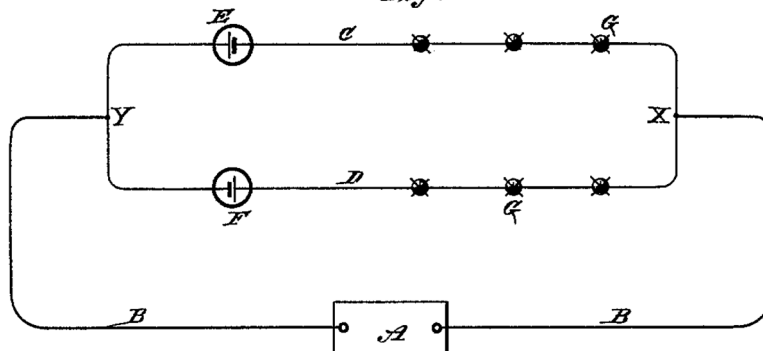


Fig. 2

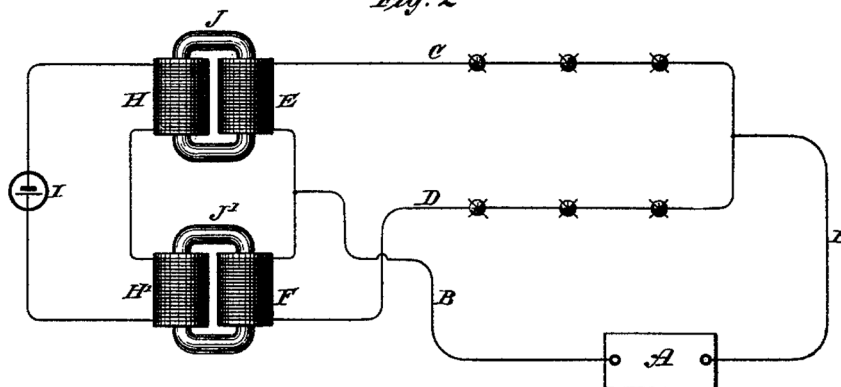
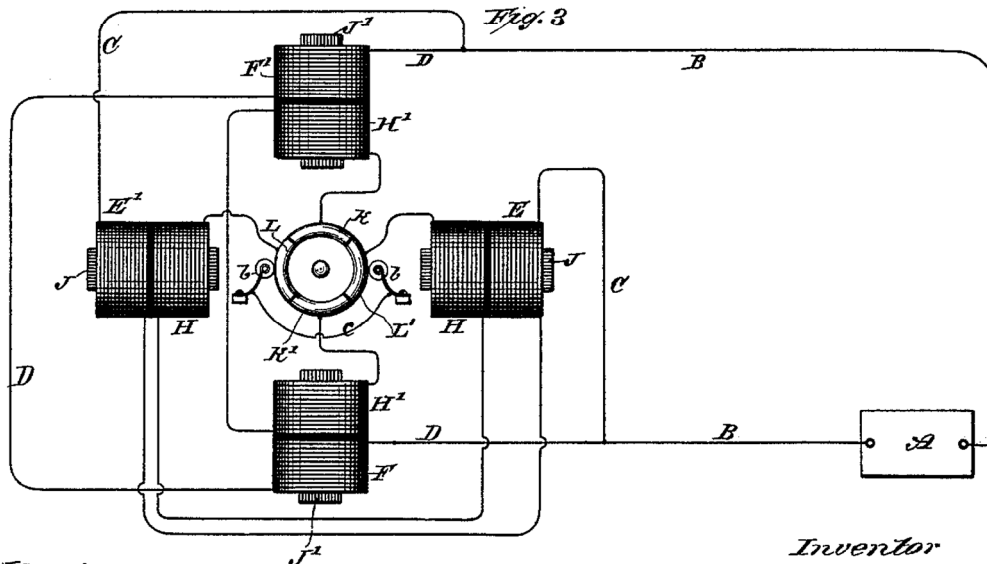


Fig. 3



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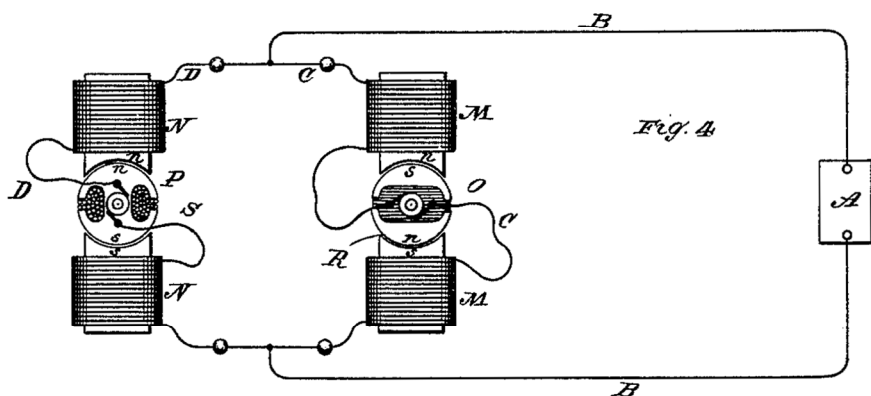


Fig. 4

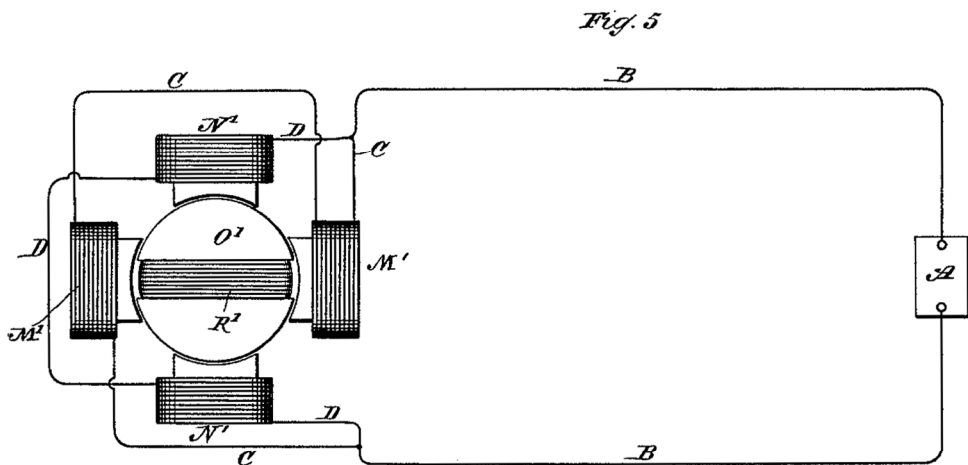


Fig. 5

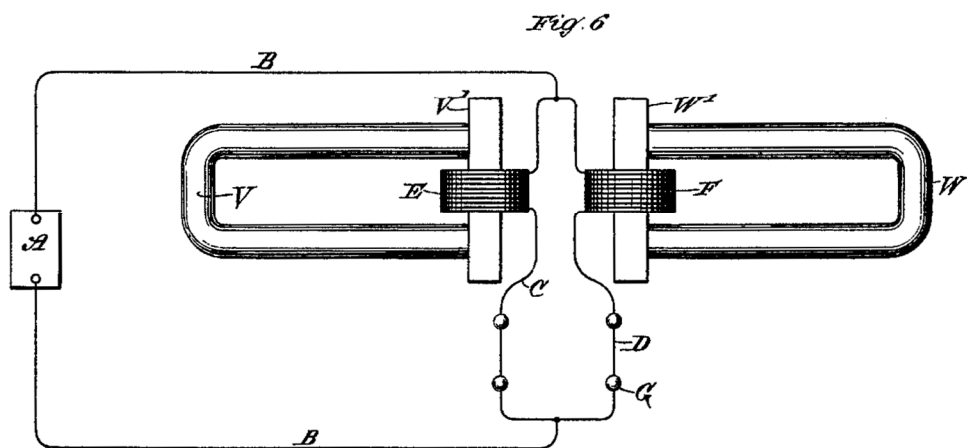


Fig. 6

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(No Model.)

3 Sheets—Sheet 3.

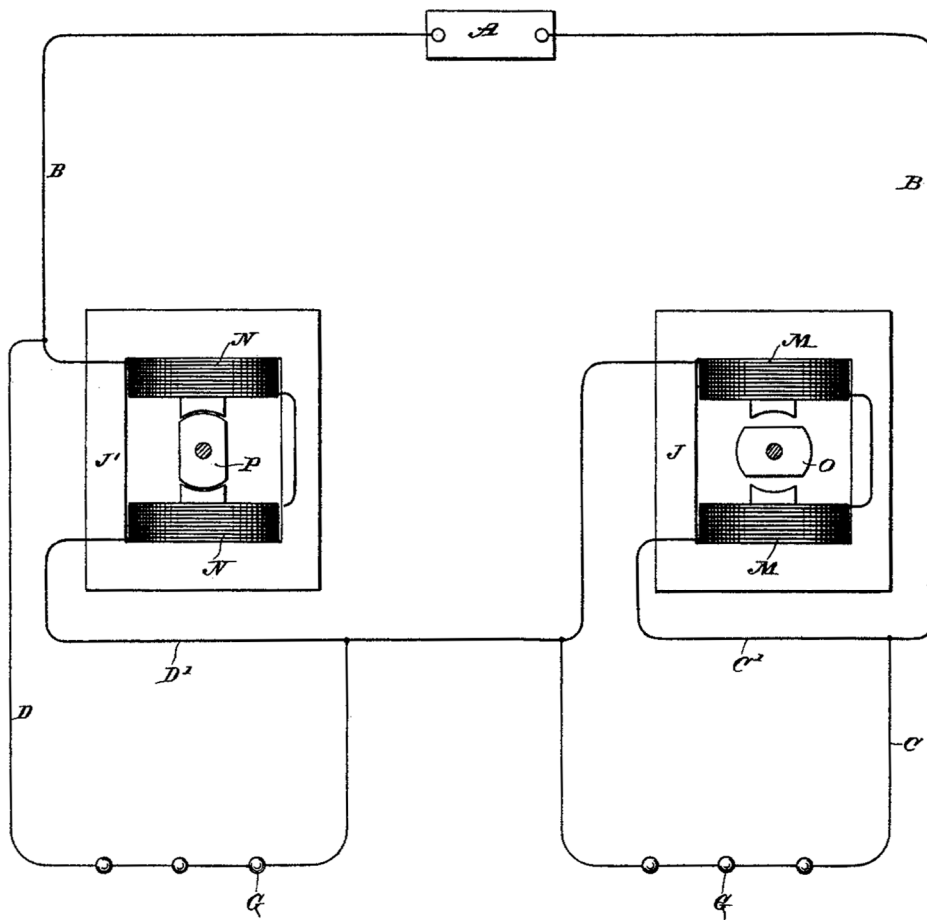
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METHOD OF OBTAINING DIRECT FROM ALTERNATING CURRENTS.

No. 413,353.

Patented Oct. 22, 1889.

Fig. 7



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Karlai Netter
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ELECTRO-MAGNETIC MOTOR.

电磁电动机

NIKOLA TESLA, OF NEW YORK, N. Y., ASSIGNOR TO THE TESLA ELECTRIC
COMPANY, OF SAME PLACE.

纽约州纽约市的尼古拉·特斯拉将专利权转让给纽约市的特斯拉电气公司

SPECIFICATION forming part of Letters Patent No. 416,191, dated December 3, 1889.

Application filed May 20, 1889. Serial No. 311,413. (No model.)

该说明书形成了颁发于 1889 年 12 月 3 日编号为 416,191 的专利证书的一部分。

申请于 1889 年 5 月 20 日提交。序列号为 311,413。(没有模型)

To all whom it may concern:

致所有相关人士:

Be it known that I, NIKOLA TESLA, a subject of the Emperor of Austria, from Smiljan, Lika, border country of Austria-Hungary, residing at New York, in the county and State of New York, have invented certain new and useful Improvements in Electro-Magnetic Motors, of which the following is a specification, reference being had to the drawings accompanying and forming a part of the same.

众所周知，我、尼古拉·特斯拉、一位奥匈帝国的臣民，来自奥匈帝国边境地区的利卡县的史密里安村，现在居住在纽约州纽约郡纽约市，在电磁电动机方面已经发明了某种新的和有用的改进，以下是该发明一个说明书，必须参考随附的图纸，它已形成该说明书的一部分。

This invention pertains to that class of electro-magnetic motors invented by me in which two or more independent energizing-circuits are employed, and through which alternating currents differing in phase are passed to produce the operation or rotation of the motor.

本发明属于我发明的电磁电动机的类别，其中采用了两个或多个独立的励磁电路，并且不同相位的交流电通过该励磁电路产生电动机的运行或旋转。

One of the general ways which I have followed in carrying out this invention is to produce practically independent currents differing primarily in phase and pass these through the motor-circuits. Another way is to produce a single alternating current, to divide it between the motor-circuits, and to effect artificially a lag in one of the said circuits or branches, as by giving to the circuits different self-inductive capacity, and in other ways. In the former case, in which the necessary difference of phase is primarily effected in the generation of currents, I have, in some instances, passed the currents through the energizing-coils of both elements of the motor—the field and armature; but I have made the discovery that a new and useful result is or may be obtained by doing this under the conditions hereinafter specified in the case of motors in which the lag, as above stated, is artificially secured. In this my present invention resides.

在实施本发明时，我所遵循的一般方法之一是产生基本上相位不同的独立电流，并使这些电流通过电动机电路。另一种方法是产生单个交流电流，在电动机的不同电路之间进行分配，并在所述电路或分支之一中人为地实现滞后，如通过给予电路不同的自感容量，以及其他方式。在前一种情况下，必要的相位差主要影响电流的产生，在某些情况下，我已经使电流通过电动机的两个组件——励磁线圈和电枢线圈；但我发现一个新的和有用的结果是通过下文指定条件下被获得或可能被获得，在这种条件中，如上文所述，滞后被人工确保了。我的发明就在于此。

In illustration of the nature of this invention I shall refer to the accompanying drawings, in which—

为了说明本发明的本质，我将参考附图，其中—

Figures 1 to 6, inclusive, are diagrams of different ways in which the invention is or may be carried out; and Fig. 7, a side view of a form of motor which I have used for this purpose.

图 1 至图 6 是实施或可能实施本发明的不同方式的示意图；图 7 是我为此目的使用的一种电动机的侧视图。

The diagrams in detail will be described separately.

这些图将被分别详细描述。

A B in Fig. 1 indicate the two energizing-circuits of a motor, and C D two circuits on the armature. Circuit or coil A is connected in series with circuit or coil C, and the two circuits B D are similarly connected. Between coils A and C is a contact-ring e, forming one terminal of the latter, and a brush a, forming one terminal of the former. A ring d and brush c similarly connect coils B and D. The opposite terminals of the field-coils connect to one binding-post h of the motor, and those of the armature-coils are similarly connected to the opposite binding-post i through a contact-ring f and brush g. Thus each motor-circuit while in derivation to the other includes one armature and one field-coil. These circuits are of different self-induction, and may be made so in various ways. For the sake of clearness I have shown in one of these circuits an artificial resistance R and in the other a self-induction coil S. When an alternating current is passed through this motor it divides between its two energizing-circuits. The higher self-induction of one circuit produces a greater retardation or lag in the current therein than in the other. The difference of phase between the two currents effects the rotation or shifting of the points of maximum magnetic effect that secures the rotation of the armature. In certain respects this plan of including both armature and field coils in circuit is a marked improvement. Such a motor has a good torque at starting; yet it has also considerable tendency to synchronism, owing to the fact that when properly constructed the maximum magnetic effects in both armature and field coincide—a condition which in the usual construction of these motors with closed armature-coils is not readily attained. The motor thus constructed exhibits, too, a better regulation of current from no load to load, and there is less difference between the apparent and real energy expended in running it. The true synchronous speed of this form of motor is that of the generator when both are alike—that is to say, if the number of the coils on the armature and on the field is x, the motor will run normally at the same speed as a generator driving it if the number of field-magnets or poles of the same be also x.

图 1 中的 A B 表示电动机的两个励磁电路，C D 表示电枢上的两个电路。电路或线圈 A 与电路或线圈 C 串联，两个电路 B 和 D 的连接方式类似。在线圈 A 和 C 之间是一个接触环 c，形成了后者的一个终端，一个电刷 A，形成前者的一个终端。环 d 和电刷 c 类似地连接线圈 B 和 D。励磁线圈的相对终端连接到电动机的一个接线柱 h，电枢线圈的相对终端通过一个接触环 f 和电刷 g 类似地连接到相对的接线柱 i。因此，每个电动机电路在相互间接相连(通过线圈进行连接)时包含了一个电枢线圈和一个励磁线圈。这些电路具有不同的自感，并且可以用不同的方法制造。为了清楚起见，我在其中一个电路中展示了一个仿真电阻 R，在另一个电路中展示了一个自感线圈 S。当一个交流电流通过这个电动机时，它在两个通电电路之间分流。一个电路的较高自感在其中产生比另一个电路更大的电流延迟或滞后。两个电流之间的相位差影响最大磁效应点的转移或移动，从而确保电枢的旋转。在某些方面，这种在电路中包含电枢和励磁线圈的方案是一个显著的改进。这样的电动机在启动时具有良好的转矩；然而，它也有相当大的同步趋势，这是由于这样一个事实，即当这个电动机被适当构建时，电枢和磁场中的最大磁效应是实时重合的——这是在具有闭合的电枢线圈的电动机的通常结构中不容易达到一个条件。这样构造的电动机也表现出从空载到负载的更好的一个电流调节，并且在运行它时消耗的表现和实际能量之间的差异更小。这种形式的电动机的真正同步速度是发电机的速度，当两者相同时——也就是说，如果电枢和磁场上的线圈数量是 x ，如果发电机的场磁体或磁极的数量也是 x ，电动机将以驱动它的发电机的相同速度正常运行。

Fig. 2 shows a somewhat modified arrangement of circuits. There is in this case but one armature-coil E, the winding of which maintains effects corresponding to the resultant poles produced by the two field-circuits.

图 2 展示了一个稍微修改的电路布置。在这种情况下，只有一个电枢线圈 E，其绕组保持的效果相当于由两个磁场电路产生的合成磁极的效果。

Fig. 3 represents a disposition in which both armature and field are wound with two sets of coils, all in multiple arc to the line or main circuit. The armature-coils are wound to correspond with the field-coils with respect to their self-induction. A modification of this plan is shown in Fig. 4—that is to say, the two field-coils and two armature-coils are in derivation to themselves and in series with one another. The armature-coils in this case, as in the previous figure, are wound for different self-induction to correspond with the field-coils.

图 3 表示一种布置，其中电枢和磁场都用两组线圈缠绕，所有线圈都与线路或主电路多弧连接（并联）。电枢线圈缠绕成与励磁线圈的自感相一致。图 4 展示了这种方案的一种改进，也就是说，两个励磁线圈和两个电枢线圈相互间接连接并相互串联。在这种情况下，如上图所示，电枢线圈被缠绕用于不同的自感，与励磁线圈相一致。

Another modification is shown in Fig. 5. In this case only one armature-coil, as D, is included in the line-circuit, while the other, as C, is short-circuited.

图 5 展示了另一种修改。在这种情况下，只有一个电枢线圈，如 D，被包含在线路中，而另一个，如 C，是短路的。

In such a disposition as that shown in Fig. 2, or where only one armature-coil is employed, the torque

on the start is somewhat reduced, while the tendency to synchronism is somewhat increased. In such a disposition, as shown in Fig. 5, the opposite conditions would exist. In both instances, however, there is the advantage of dispensing with one contact-ring.

在如图 2 所示的一个配置中，或者在仅使用一个电枢线圈的情况下，启动时的转矩有所降低，而同步的趋势有所增加。在这种配置中，如图 5 所示，将存在相反的条件。然而，在这两种情况下，都有省去一个接触环的优点。

In Fig. 5 the two field-coils and the armature-coil D are in multiple arc. In Fig. 6 this disposition is modified, coil D being shown in series with the two field-coils.

在图 5 中，两个励磁线圈和电枢线圈 D 多弧连接。在图 6 中，这种布置被修改，线圈 D 被展示为与两个励磁线圈串联。

Fig. 7 is an outline of the general form of motor in which I have embodied this improvement. The circuit-connections between the armature and field coils are made, as indicated in the previous figures, through brushes and rings, which are not shown.

图 7 是我已经实施这种改进的电动机的总体形式的轮廓。如前图所示，电枢线圈和励磁线圈之间的电路连接是通过电刷和环(未展示)实现的。

In the above description I have made use of the terms “armature” and “field”; but it will be understood that these are in this case convertible terms, for what is true of the field is equally so of the armature, except that one is stationary, the other capable of rotation.

在上面的描述中，我已经使用了术语“电枢”和“场”；但可以理解的是，在这种情况下，这些是可转换的术语，因为场的真实情况同样适用于电枢，只是一个静止的，另一个能够旋转。

I do not claim in this application the method or means of operating a double-circuit motor by making its circuits of different self-induction or in any way retarding the phases of current in one circuit more than in another, having made these features subject of other applications; but

在本申请中，我没有主张通过使双电路电动机的电路具有不同的自感或以任何方式使一个电路中的电流相位比另一个电路中的电流相位延迟更多来运行双电路电动机的方法或手段，已经使这些特征成为其他申请的主题；但

What I claim is—

我主张的是—

1. In an alternating-current motor, the combination, with field-circuits of different self-inductive capacity, of corresponding armature-circuits electrically connected therewith, as set forth.

1、如上所述，在一个交流电动机中，具有不同自感量的励磁电路与相应的电枢电路的组合。

2. In an alternating-current motor, the combination, with independent field-coils of different self-induction, of independent armature-coils, one or more in circuit with the field-coils and the others short-circuited, as set forth.

2、如上所述，在一个交流电动机中，独立的电枢线圈与不同自感的独立励磁线圈的组合，其中一个或多个电枢线圈与励磁线圈在电路中，其他电枢线圈被短路。

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N. TESLA.
ELECTRO MAGNETIC MOTOR.

No. 416,191.

Patented Dec. 3, 1889.

Fig. 1

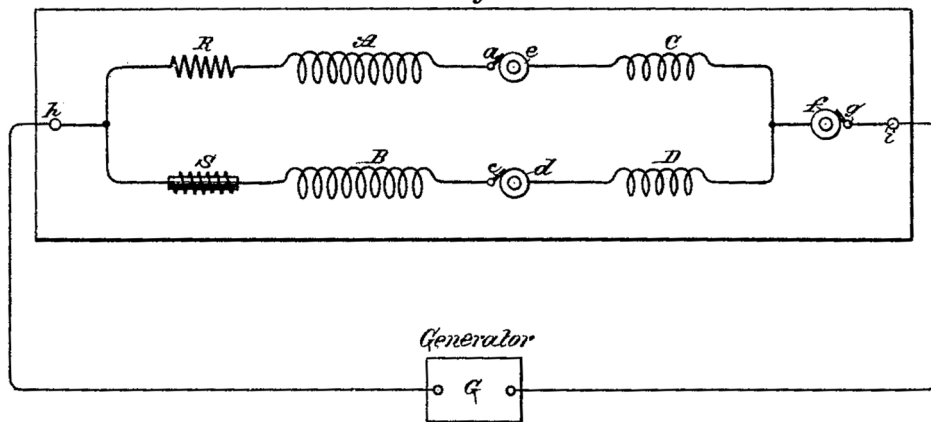


Fig. 2

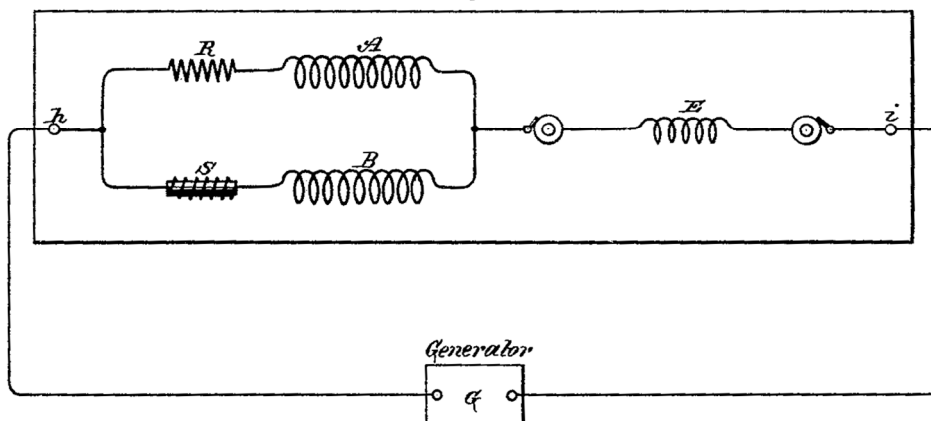
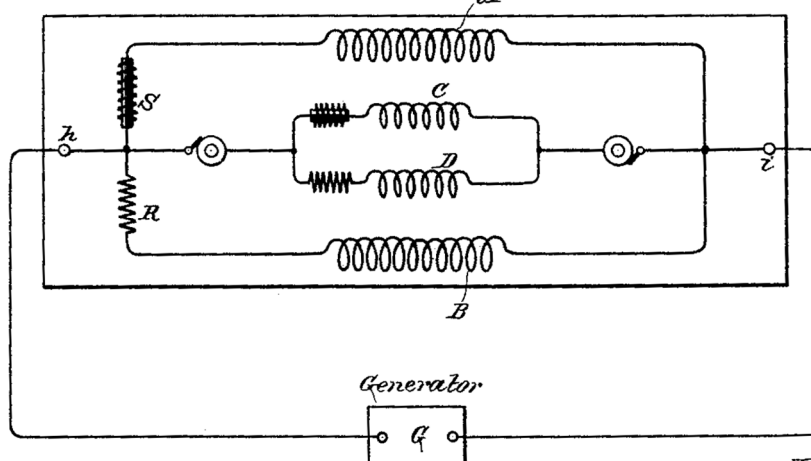


Fig. 3



Witnesses:

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ELECTRO MAGNETIC MOTOR.

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Patented Dec. 3, 1889.

Fig. 4.

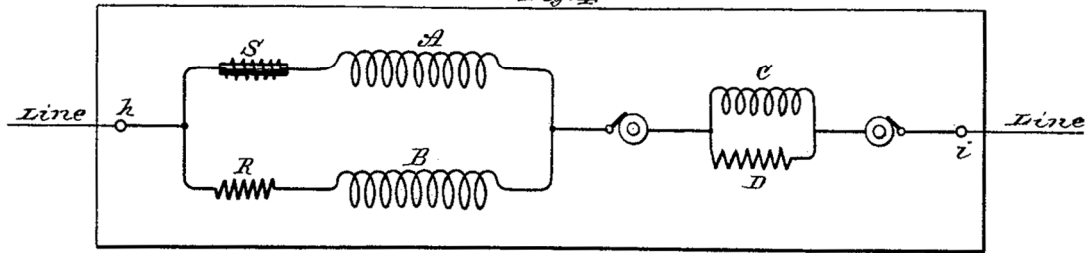


Fig. 5.

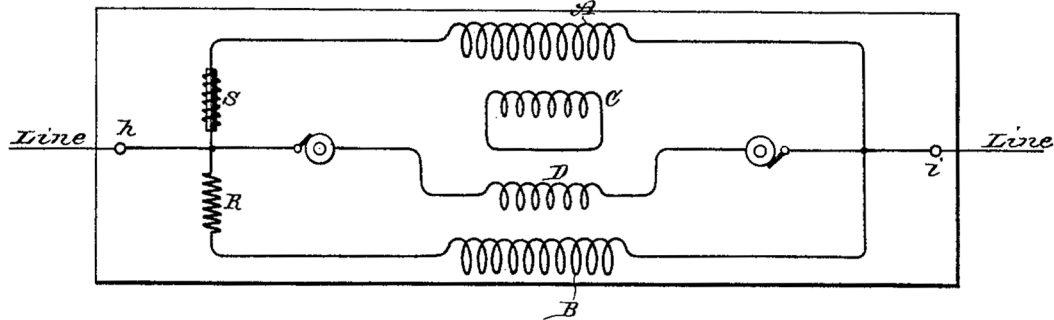


Fig. 6.

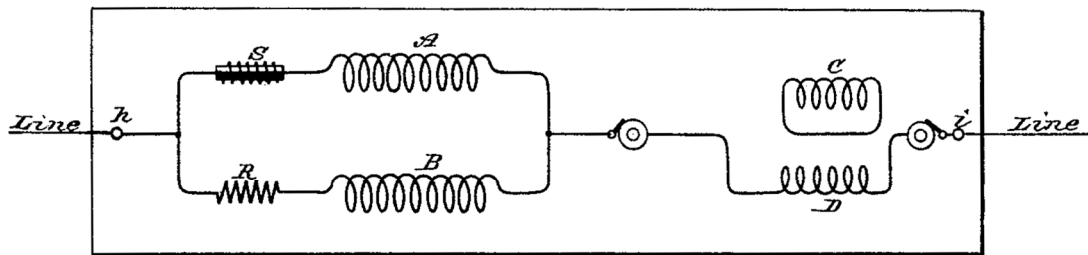
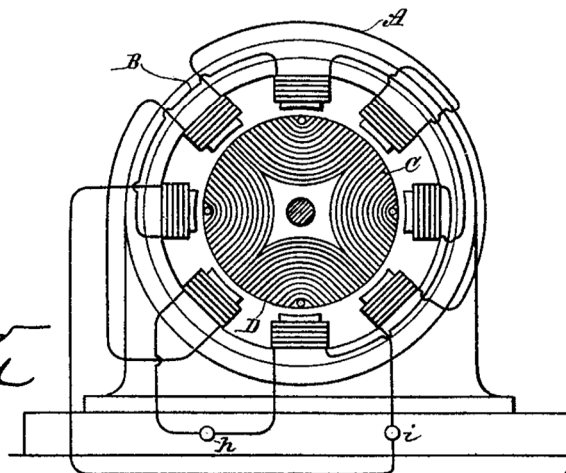


Fig. 7.



Witnesses:
Hartail Netter
Robt. F. Gaylord

Inventor
Nikola Tesla
By Duncan,
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Attorneys.

METHOD OF OPERATING ELECTRO-MAGNETIC MOTORS.

运行电磁电动机的方法

NIKOLA TESLA, OF NEW YORK, N. Y., ASSIGNOR TO THE TESLA ELECTRIC COMPANY, OF SAME PLACE.

纽约州纽约市的尼古拉·特斯拉将专利权转让给纽约市的特斯拉电气公司

SPECIFICATION forming part of Letters Patent No. 416,192, dated December 3, 1889.

Application filed May 20, 1889. Serial No. 311,414. (No model.)

该说明书形成了颁发于 1889 年 12 月 3 日编号为 416,192 的专利证书的一部分。

申请于 1889 年 5 月 20 日提交。序列号为 311,414。(没有模型)

To all whom it may concern:

致所有相关人士:

Be it known that I, NIKOLA TESLA, a subject of the Emperor of Austria, from Smiljan, Lika, border country of Austria-Hungary, and a resident of New York, in the county and State of New York, have invented certain new and useful Improvements in Methods of Operating Electro-Magnetic Motors, of which the following is a specification, reference being had to the drawings accompanying and forming a part of the same.

众所周知，我、尼古拉·特斯拉、一位奥匈帝国的臣民，来自奥匈帝国边境地区的利卡县的史密里安村，也是纽约州纽约郡纽约市的一位居民，在运行电磁电动机的方法方面已经发明了某种新的和有用的改进，以下是该发明一个说明书，必须参考随附的图纸，它已形成该说明书的一部分。

In a patent granted to me April 16, 1889, No. 401,520, I have shown and described a method of starting and operating synchronizing motors which involved the transformation of the motor from a torque to a synchronizing motor. This I have heretofore done by a change of the circuit-connections, whereby on the start the poles or resultant attraction of the field-magnets of the motor were shifted or rotated by the action of the current until the motor reached synchronous speed, after which the poles were merely alternated. The present application is based upon another way of accomplishing this result, the main features being as follows: If an alternating current be passed through the field-coils only of a motor having two energizing-circuits of different self-induction and the armature-coils be short-circuited, the motor will have a strong torque, but little or no tendency to synchronism with the generator; but if the same current which energizes the field be passed also through the armature-coils the tendency to remain in synchronism is very considerably increased. This is due to the fact that the maximum magnetic effects produced in the field and armature more nearly coincide. This principle discovered by me I have utilized in the operation of motors. In other words, I construct a motor having independent field-circuits of different self-induction, which are joined in derivation to a source of

alternating currents. The armature I wind with one or more coils, which are connected with the field-coils through contact rings and brushes, and around the armature-coils I arrange a shunt with means for opening or closing the same. In starting this motor I close the shunt around the armature-coils, which will therefore be in closed circuit. When the current is directed through the motor, it divides between the two circuits, (it is not necessary to consider any case where there are more than two circuits used,) which, by reason of their different self-induction, secure a difference of phase between the two currents in the two branches that produces a shifting or rotation of the poles. By the alternations of current other currents are induced in the closed—or short-circuited—armature-coils and the motor has a strong torque. When the desired speed is reached, the shunt around the armature-coils is opened and the current is directed through both armature and field-coils. Under these conditions the motor has a strong tendency to synchronism.

在 1889 年 4 月 16 日授予我的专利号为 401,520 的专利中, 我展示并描述了一种启动和运行同步电动机的方法, 该方法包括将电动机从一个转矩转换成一个同步电动机。迄今为止, 我通过电路连接的一个改变来实现这一点, 由此在启动时, 电动机的磁极或由此产生的吸引力在电流的作用下转移或旋转, 直到电动机达到同步速度, 在此之后磁极只是交替。本申请基于实现该结果的另一种方式, 其主要特征如下: 如果一个交流电流只通过具有不同自感的两个励磁电路的一个电动机的励磁线圈, 并且电枢线圈短路, 则电动机将具有一个很强的转矩, 但很少或没有与发电机同步的趋势; 但如果激发磁场的相同电流也通过电枢线圈, 则保持同步的趋势就会大大增加。这是因为磁场和电枢中产生的最大磁效应更接近实时重合。这个由我发现的原理我已经用在电动机的运行上。换句话说, 我构建了一台具有不同自感应的独立磁场电路的电动机, 这些电路间接连接(通过能延迟电流相位的线圈进行连接)到一个交流电源。电枢 I 缠绕有一个或多个线圈, 这些线圈通过接触环和电刷与励磁线圈连接, 并且在电枢线圈 I 周围布置有一个分流器, 该分流器具有用于断开或闭合该分流器的工具。在启动这个电动机时, 我闭合了电枢线圈周围的分流器, 因此它将处于闭合电路中。当电流被引导通过电动机时, 它在两个电路之间分流(没有必要考虑使用两个以上电路的任何情况), 由于这两个电路不同的自感, 确保了在两个分支中的两个电流之间的相位差, 这产生了磁极的转移或旋转。通过电流的变化, 在闭合的或短路的电枢线圈中感应出其他电流, 电动机具有强大的转矩。当达到所需速度时, 电枢线圈周围的分流器断开, 电流流过电枢和励磁线圈。在这些条件下, 电动机有一个很强的同步倾向。

In the drawings hereto annexed I have illustrated several modifications of the plan above set forth for operating motors. The figures are diagrams, and will be explained in their order.

在所附的附图中, 我已经说明了上述用于运行电动机的方案的几个修改。这些图是示意图, 将按顺序进行解释。

Figure 1: A and B designate the field-coils of the motor. As the circuits including these coils are of different self-induction, I have represented this by a resistance-coil R in circuit with A, and a self-induction coil S in circuit with B. The same result may of course be secured by the winding of the coils. C is the armature-circuit, the terminals of which are rings a b. Brushes c d bear on these rings and connect with the line and field circuits. D is the shunt or short circuit around the armature. E is the switch therein. The operation of these devices I have stated above.

图 1: A 和 B 表示电动机的励磁线圈。由于包含这些线圈的电路具有不同的自感, 我用电路

中的电阻线圈 R 和电路中的自感线圈 S 来表示。同样的结果当然可以通过线圈的缠绕来保证。C 是电枢电路，其终端是环 a b，电刷 c d 倚靠在这些环上，并与线路和励磁电路相连。D 是电枢周围的分流或短路。E 是其中的开关。这些设备的操作我已经在上面陈述过了。

It will be observed that in such a disposition as is illustrated in Fig. 1, the field-circuits A and B being of different self-induction, there will always be a greater lag of the current in one than the other, and that, generally, the armature phases will not correspond with either, but with the resultant of both. It is therefore important to observe the proper rule in winding the armature. For instance, if the motor have eight poles—four in each circuit—there will be four resultant poles, and hence the armature-winding should be such as to produce four poles, in order to constitute a true synchronizing motor.

可以看出，在图 1 所示的布置中，励磁电路 A 和 B 具有不同的自感，其中一个电路中的电流总是比另一个电路中的电流滞后更大，并且通常电枢相位不会与其中任何一个相一致，而是与两者的合成相位一致。因此，在缠绕电枢绕组时遵守正确的规则很重要。例如，如果电动机有 8 个极——每个电路有 4 个极——将有 4 个合成磁极，因此电枢绕组应该产生 4 个磁极，以便构成一个真正的同步电动机。

Fig. 2: This diagram differs from the previous one only in respect to the order of connections. In the present case the armature-coil, instead of being in series with the field-coils, is in multiple arc therewith. The armature-winding may be similar to that of the field—that is to say, the armature may have two or more coils wound or adapted for different self-induction and adapted, preferably, to produce the same difference of phase as the field-coils. On starting the motor the shunt is closed around both coils. This is shown in Fig. 3, in which the armature-coils are F G. To indicate their different electrical character, I have shown in circuit with them, respectively, the resistance R' and the self-induction coil S'. The two armature coils are in series with the field-coils and the same disposition of the shunt or short circuit D is used. It is of advantage in the operation of motors of this kind to construct or wind the armature in such manner that when short-circuited on the start it will have a tendency to reach a higher speed than that which synchronizes with the generator. For example, a given motor having, say, eight poles should run, with the armature-coil short-circuited, at two thousand revolutions per minute to bring it up to synchronism. It will generally happen, however, that this speed is not reached, owing to the fact that the armature and field currents do not properly correspond, so that when the current is passed through the armature (the motor not being quite up to synchronism) there is a liability that it would not “hold on,” as it is termed. I therefore prefer to so wind or construct the motor that on the start, when the armature-coils are short-circuited, the motor will tend to reach a speed higher than the synchronous—as, for instance, double the latter. In such case the difficulty above alluded to is not felt, for the motor will always hold up to synchronism if the synchronous speed—in the case supposed of two thousand revolutions—is reached or passed. This may be accomplished in various ways; but for all practical purposes the following will suffice: I wind on the armature two sets of coils. On the start I short-circuit one only, thereby producing a number of poles on the armature, which will tend to run the speed up above the synchronous limit. When such limit is reached or passed, the current is directed through the other coil, which, by increasing the number of armature-poles, tends to maintain synchronism. In Fig. 4 such a disposition is shown. The motor having, say, eight poles contains two field-circuits A and B, of different self-induction. The armature has two coils F and G. The former is closed upon itself, the latter connected with the field and line through contact-rings a b, brushes c d, and a switch E. On the start the coil F alone is active and the motor tends to run at a speed above the synchronous; but when

the coil G is connected to the circuit the number of armature-poles is increased, while the motor is made a true synchronous motor. This disposition has the advantage that the closed armature-circuit imparts to the motor torque when the speed falls off, but at the same time the conditions are such that the motor comes out of synchronism more readily. To increase the tendency to synchronism, two circuits may be used on the armature, one of which is short-circuited on the start and both connected with the external circuit after the synchronous speed is reached or passed. This disposition is shown in Fig. 5. There are three contact-rings a b c and three brushes c d f, which connect the armature-circuits with the external circuit. On starting, the switch H is turned to complete the connection between one binding-post P and the field-coils. This short-circuits one of the armature-coils, as G. The other coil F is out of circuit and open. When the motor is up to speed, the switch H is turned back, so that the connection from binding-post P to the field-coils is through the coil G, and switch K is closed, thereby including coil F in multiple arc with the field-coils. Both armature-coils are thus active.

图 2: 这个图与上一个图的不同之处仅在于连接的顺序。在这种情况下, 电枢线圈不是与励磁线圈串联, 而是与其成多弧连接 (并联)。电枢绕组可以类似于励磁绕组, 也就是说, 电枢可以具有两个或更多的线圈, 这些线圈被缠绕或适用于不同的自感, 并且最好适用于产生与这些励磁线圈相同的相位差。启动电动机时, 两个线圈周围的分流器闭合。这在图 3 中展示出, 其中电枢线圈是 F G。为了表示它们不同的电特性, 我在电路中分别用电阻 R' 和自感线圈 S' 表示。两个电枢线圈与这些励磁线圈串联, 并且使用相同的分流电路 D 或短路电路 D 的配置。在这种类型的电动机的运行中, 以这样的方式构建或缠绕电枢是有利的, 即在启动电动机时对它进行短路, 它将倾向于达到比与发电机同步的速度更高的速度。例如, 一台具有 8 个磁极的给定电动机应该在电枢线圈短路的情况下以每分钟两千转的速度运转, 以使其达到同步状态。然而, 由于电枢电流和励磁电流没有正确对应, 因此通常会发生无法达到该速度的情况, 所以当电流通过电枢时 (电动机没有完全达到同步), 不会有正如名字所称的“抓牢”的倾向。因此, 我更喜欢这样缠绕或构造电动机, 在开始时, 当电枢线圈被短路时, 电动机将倾向于达到比同步更高的速度——例如, 后者的两倍。在这种情况下, 上面提到的困难是感觉不到的, 因为如果达到或超过同步速度——在假设同步速度是两千转的情况下——电动机将总是保持同步。这可以通过多种方式实现; 但是对于所有实际目的, 以下内容就足够了: 我在电枢上缠绕了两组线圈。在开始时, 我只短路一组, 从而在电枢上产生许多磁极, 这将使速度超过同步限度。当达到或超过这种极限时, 电流被引导通过另一个线圈, 通过增加电枢磁极的数量, 该线圈倾向于保持同步。在图 4 中展示了这样的布置。比如说, 有 8 个磁极的电动机包含两个不同自感的励磁电路 A 和 B。电枢有两个线圈 F 和 G。前者自我闭合, 后者通过接触环 a b c 和电刷 c d 和一个开关 E 与励磁和线路相连。在启动时, 只有线圈 F 是起作用的, 电动机倾向于以一个高于同步的速度运行; 但是当线圈 G 连接到电路时, 电枢极数增加, 而电动机成为真正的同步电动机。这种配置的优点是, 当速度下降时, 闭合的电枢电路向电动机施加转矩, 但同时条件是电动机更容易失去同步。为了增加同步的趋势, 电枢上可以使用两个电路, 其中一个在启动时短路, 在达到或超过同步速度后, 这两个电路都与外部电路连接。这种布置如图 5 所示。有三个接触环 a b c 和三个电刷 c d f, 它们将电枢电路与外部电路连接起来。在启动时, 开关 H 被转动以完成接线柱 P 和励磁线圈之间的连接。这会短路电枢线圈之一, 如 G。另一个线圈 F 不在电路中并且开路。当电动机达到速度时, 开关 H 转回, 使得从接线柱 P 到励磁线圈的连接要经过线圈 G, 并且开关 K 闭合, 从而包含了与多个励磁线圈多弧连接的线圈 F。因此两个电枢线圈都被激活。

From the above-described instances it is evident that many other dispositions for carrying out the invention are possible.

从上面描述的例子中，很明显，用于实施本发明的许多其他布置也是可以的。

I do not claim herein the method and means described and shown for operating a motor by producing artificially a difference of current phase in its independent energizing-circuits; nor do I claim, broadly, a motor having independent energizing-circuits of different self-induction and armature-circuits connected therewith, as these features are made subjects of other applications which I have filed.

我在此并不主张所描述和展示的通过在独立的激励电路中人为产生电流相位差来运行电动机的方法和工具；从广义上讲，我也不主张具有不同自感的独立励磁电路和与之连接的电枢电路的电动机，因为这些特征是我已经提交的其他申请的主题。

What I claim is—

我主张的是—

1. The method herein described of operating alternating-current motors having independent energizing-circuits, which consists in short-circuiting the armature circuit or circuits until the motor has reached or passed a synchronizing speed and then connecting said armature-circuits with the external circuit, as set forth.

1、这里描述的运行具有独立励磁电路的交流电动机的方法，包括短路电枢的一个电路或多个电路，直到电动机已经达到或超过同步速度，然后将所述电枢电路与外部电路连接，如上所述。

2. The method of operating alternating-current motors having field-coils of different self-induction, which consists in directing alternating currents from an external source through the field-circuits only until the motor has reached a given speed and then directing said currents through both the field-circuits and one or more of the armature-circuits, as set forth.

2、运行具有不同自感的励磁线圈的交流电动机的方法，该方法包括引导来自一个外部电源的交流电通过励磁电路，直到电动机达到一个给定速度，然后引导所述电流通过励磁电路和一个或多个电枢电路，如上所述。

3. The method of operating alternating-current motors having field-coils of different self-induction, which consists in directing alternating currents from an external source through the field-circuits and short-circuiting a part of the armature-circuits, and then when the motor has attained a given speed directing the alternating currents through both the field and one or more of the armature-circuits, as set forth.

3、运行具有不同自感的励磁线圈的交流电动机的方法，该方法包括引导来自一个外部电源的交流电通过励磁电路并将一部分电枢电路短路，然后当电动机达到给定速度时，引导交流电通过励磁电路和一个或多个电枢电路，如上所述。

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尼古拉·特斯拉

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N. TESLA.

METHOD OF OPERATING ELECTRO MAGNETIC MOTORS.

No. 416,192.

Patented Dec. 3, 1889.

Fig. 1

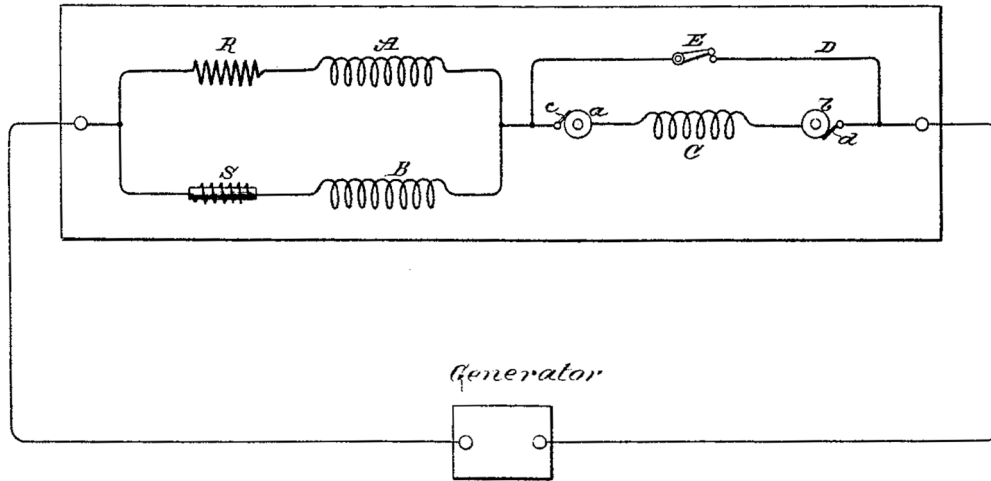


Fig. 2

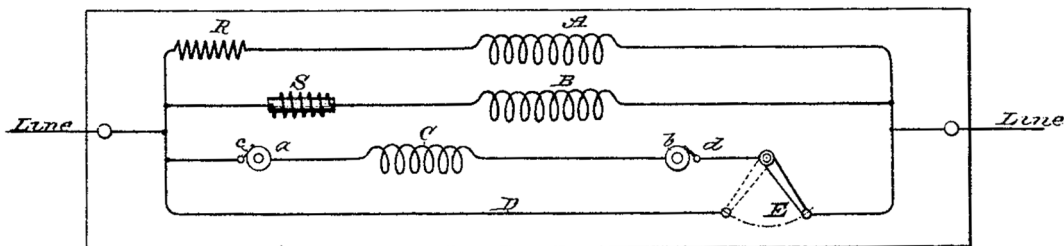
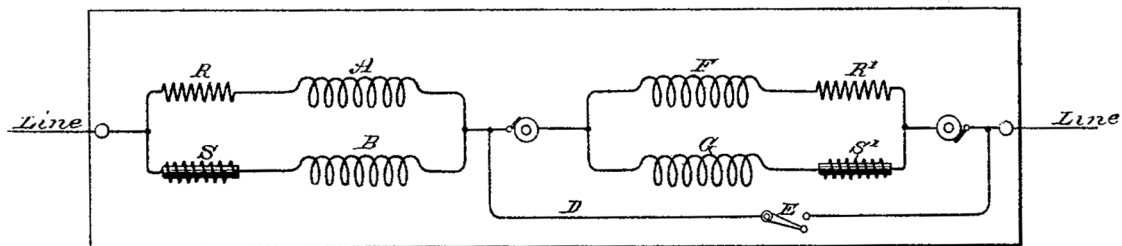


Fig. 3



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N. TESLA.

METHOD OF OPERATING ELECTRO MAGNETIC MOTORS.

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Fig. 4

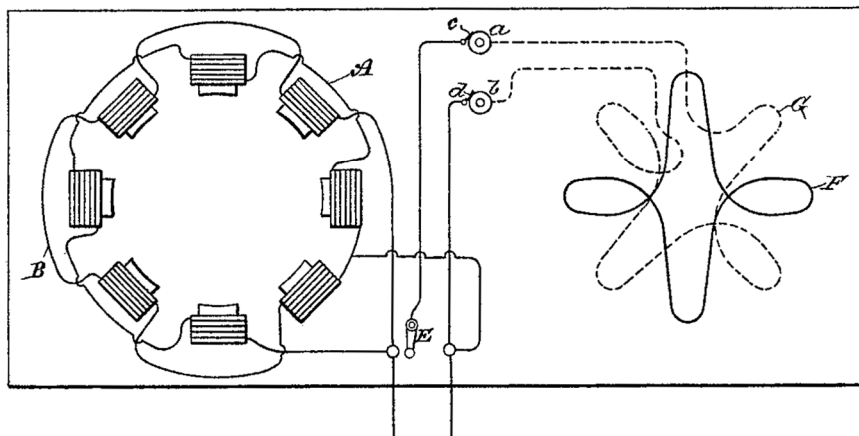
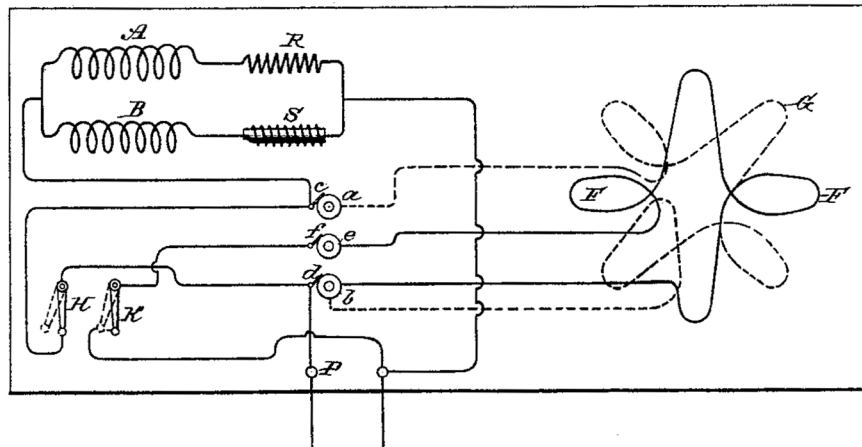


Fig. 5



Witnesses:

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ELECTRO-MAGNETIC MOTOR.

电磁电动机

NIKOLA TESLA, OF NEW YORK, N. Y., ASSIGNOR TO THE TESLA ELECTRIC
COMPANY, OF SAME PLACE.

纽约州纽约市的尼古拉·特斯拉将专利权转让给纽约市的特斯拉电气公司

SPECIFICATION forming part of Letters Patent No. 416,193, dated December 3, 1889.

Application filed May 20, 1889. Serial No. 311,415. (No model.)

该说明书形成了颁发于 1889 年 12 月 3 日编号为 416,193 的专利证书的一部分。

申请于 1889 年 5 月 20 日提交。序列号为 311,415。(没有模型)

To all whom it may concern:

致所有相关人士:

Be it known that I, NIKOLA TESLA, a subject of the Emperor of Austria, from Smiljan, Lika, border country of Austria-Hungary, residing at New York, in the county and State of New York, have invented certain new and useful Improvements in Electro-Magnetic Motors, of which the following is a specification, reference being had to the accompanying drawings.

众所周知，我、尼古拉·特斯拉、一位奥匈帝国的臣民，来自奥匈帝国边境地区的利卡县的史密里安村，现在居住在纽约州纽约郡纽约市，在电磁电动机方面已经发明了某种新的和有用的改进，以下是该发明一个说明书，必须参考随附的图纸。

This invention relates to alternating-current motors of the general description invented by me, and in which two or more energizing-circuits are employed, through which alternating currents differing in phase are passed, with the result of producing a progressive shifting or rotation of the poles or points of maximum attractive effect.

本发明涉及由我发明的一般描述的交流电动机，并且其中采用两个或多个励磁电路，相位不同的交流电流通过该励磁电路，结果产生具有最大吸引效应的磁极或点的渐进转移或旋转。

In prior patents and applications I have shown and described various forms of motors of this kind. Among them are motors in which both energizing-circuits are electrically alike—that is to say, both have the same or approximately the same electrical resistance and self-induction—in the operation of which the alternating currents used are primarily of different phase. In others the difference of phase is artificially produced—as, for instance, in cases where the motor-circuits are of different resistance and self-induction, so that the same current divided between them will be retarded in one to a greater extent than in the other, and the requisite phase difference secured in this way. To this latter class generally my present invention relates.

在以前的专利和申请中，我已经展示和描述了这种类型的电动机的各种形式。其中有这样的

电动机，它的两个励磁电路在电气上是相似的，也就是说，两者具有相同或近似相同的电阻和自感，在运行中所用的交流电主要是不同相位的。在其他情况下，相位差是人为产生的——例如，在电动机电路具有不同的电阻和自感的情况下，因此它们之间分配的相同电流将在一个电路上比在另一个电路上有更大程度的延迟，并且以这种方式确保了必要的相位差。我的本发明通常与后一类有关。

The lag or retardation of the phases of an alternating current is directly proportional to the self-induction and inversely proportional to the resistance of the circuit through which the current flows. Hence, in order to secure the proper difference of phase between the two motor-circuits, it is desirable to make the self-induction in one much higher and the resistance much lower than the self-induction and resistance, respectively, in the other. At the same time the magnetic quantities of the two poles or sets of poles which the two circuits produce should be approximately equal. These requirements, which I have found to exist in motors of this kind, have led me to the invention of a motor having the following general characteristics: The coils which are included in that energizing-circuit which is to have the higher self-induction I make of coarse wire, or a conductor of relatively low resistance, and I use the greatest possible length or number of turns. In the other set of coils I use a comparatively few turns of finer wire or a wire of higher resistance. Furthermore, in order to approximate the magnetic quantities of the poles excited by these coils, I use in the self-induction circuit cores much longer than those in the other or resistance circuit. I have shown in the drawings a motor embodying these features.

一个交流电的相位的滞后或延迟与自感成正比，与电流流过的电路的电阻成反比。因此，为了确保两个电动机电路之间的适当相位差，最好使一个电路中的自感比另一个电路中的自感高得多，电阻比另一个电路中的电阻低得多。同时，两个电路产生的两个磁极或磁极组的磁量应该大致相等。我已经发现在这种类型的电动机中存在的这些要求，使我发明了一种具有以下总体特征的电动机：被包含在具有较高自感的励磁电路中的线圈由粗导线或相对较低电阻的导体制成，并且我使用最大可能的长度或匝数。在另一组线圈中，我使用了相对较少匝数的细的或电阻较高的一条导线。此外，为了近似计算由这些线圈励磁的磁极的磁量，我在自感电路中使用比在其他电路或电阻电路中长得多的铁芯。我已经在附图中展示了体现这些特征的电动机。

Figure 1 is a part-sectional view of the motor at right angles to the shaft. Fig. 2 is a diagram of the field-circuits.

图 1 是电动机的与轴成直角的局部截面图。图 2 是励磁电路的示意图。

In Fig. 2, let A represent the coils in one motor-circuit, and B those in the other. The circuit A is to have the higher self-induction. I therefore use a long length or a large number of turns of coarse wire in forming the coils of this circuit. For the circuit B, I use a smaller conductor, or a conductor of a higher resistance than copper, such as German silver or iron, and wind the coils with fewer turns. In applying these coils to a motor I build up a field-magnet of plates C, of iron or steel, secured together in the usual manner by bolts D. Each plate is formed with four (more or less) long cores E, around which is a space to receive the coil and an equal number of short projections F to receive the coils of the resistance-circuit. The plates are generally annular in shape, having an open space in the center for receiving the armature G, which I prefer to wind with closed coils. An alternating current divided between the two circuits is retarded as to its phases in the circuit A to a much greater extent than in the

circuit B. By reason of the relative sizes and disposition of the cores and coils the magnetic effect of the poles E and F upon the armature closely approximate. These conditions are well understood and readily secured by one skilled in the art.

在图 2 中, A 代表一个电动机电路中的线圈, B 代表另一个电路中的线圈。电路 A 将具有较高的自感。因此,我在形成这个电路的线圈时使用了一个大长度或一个大数量匝数的粗导线。对于电路 B,我使用一个更小的导体,或比铜的电阻更高的导体,如锌白铜或铁,并以更少的匝数缠绕线圈。在将这些线圈应用于一个电动机时,我制作了由铁质或钢质的板 C 组成的一个场磁体,用螺栓 D 以通常的方式固定在一起。每个板由四个(或多或少)长的铁芯 E 形成,铁芯 E 周围是一个空间,用来接受线圈和与电阻电路的线圈数量相等数量的短突起 F。这些板通常是环形的,在中心有一个开放的空间用于接受电枢 G,我更喜欢用闭合线圈缠绕电枢 G。在两个电路之间的被分配的交流电在电路 A 中的相位延迟比在电路 B 中大得多。由于铁芯和线圈的相对尺寸和布置,磁极 E 和 F 对电枢的磁效应非常接近。这些条件被本领域的技术人员很好地理解并容易确保。

An important result secured by the construction herein shown of the motor is, that these coils which are designed to have the higher self-induction are almost completely surrounded by iron, by which the retardation is considerably increased.

此处所示的电动机结构所确保的一个重要结果是,这些被设计成具有较高自感的线圈几乎完全被铁包围,由此大大增加了延迟。

I do not claim herein, broadly, the method and means of securing rotation by artificially producing a greater lag of the current in one motor-circuit than in the other, nor the use of poles or cores of different magnetic susceptibility, as these are features which I have specially claimed in other applications filed by me.

在此,广义上,我不主张通过人为地在一个电动机电路中产生比在另一个电路中更大的电流延迟来确保旋转的方法和装置,也不主张使用不同磁化率的磁极或铁芯,因为这些是我在自己提交的其他申请中特别主张的特征。

What I claim is—

我主张的是—

1. An alternating-current motor having two or more energizing-circuits, the coils of one circuit being composed of conductors of large size or low resistance and those of the other of fewer turns of wire of smaller size or higher resistance, as set forth.

1、一种具有两个或多个励磁电路的交流电机,一个电路的线圈由大尺寸或低电阻的导体组成,另一个电路的线圈由更少匝数的小尺寸或高电阻的导线组成,如前所述。

2. In an alternating-current motor, the combination, with long and short field-cores, of energizing-coils included in independent circuits, the coils on the longer cores containing an excess of copper or conductor over that in the others, as set forth.

2、在一个交流电动机中，被包含在独立电路中的励磁线圈与长的和短的励磁铁芯的组合，长铁芯上的线圈比其他铁芯上的线圈含有过量的铜或导体，如前所述。

3. The combination, with a field-magnet composed of magnetic plates having an open center and pole-pieces or cores of different length, of coils surrounding said cores and included in independent circuits, the coils on the longer cores containing an excess of copper over that in the others, as set forth.

3、存在一个组合，它包括由具有一个开放中心的一个磁性板和不同长度的极靴或铁芯组成的一个场磁体、围绕所述铁芯并被包含在独立电路中的线圈，较长铁芯上的线圈比其它铁芯上的线圈含有过量的铜，如前所述。

4. The combination, with a field-magnet composed of magnetic plates having an open center and pole-pieces or cores of different length, of coils surrounding said cores and included in independent circuits, the coils on the longer cores containing an excess of copper over that in the others and being set in recesses in the iron core formed by the plates, as set forth.

4、存在一个组合，它包括由具有一个开放中心的一个磁性板和不同长度的极靴或铁芯组成的一个场磁体、围绕所述铁芯并被包含在独立电路中的线圈，较长铁芯上的线圈比其它铁芯上的线圈含有过量的铜，并被设置在由板形成的铁芯的凹槽中，如上所述。

NIKOLA TESLA.

尼古拉·特斯拉

Witnesses:

ROBT. F. GAYLORD,

FRANK E. HARTLEY.

见证人:

罗伯特·F·盖洛德、弗兰克·E·哈特利。

(No Model.)

N. TESLA.
ELECTRO MAGNETIC MOTOR.

No. 416,193.

Patented Dec. 3, 1889.

Fig. 1

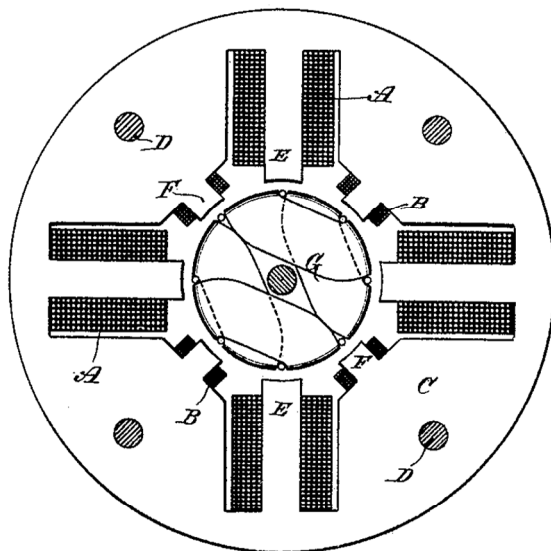
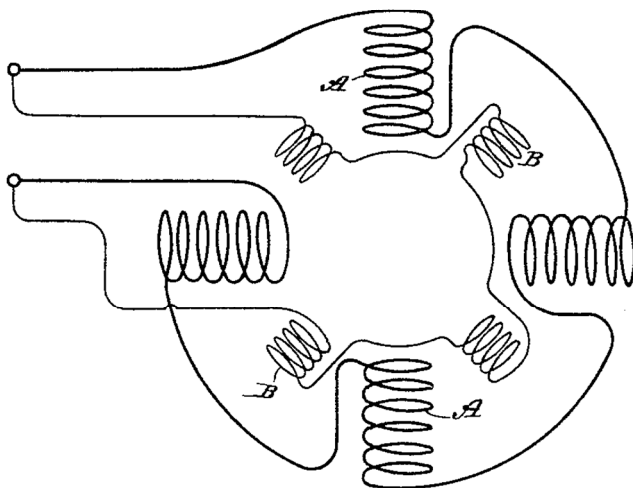


Fig. 2



Witnesses:

Raphael Netter

Robert F. Paylord

Inventor

Nikola Tesla

By

Duncan, Curtis & Page

Attorneys.

ELECTRIC MOTOR.

电动机

NIKOLA TESLA, OF NEW YORK, N. Y., ASSIGNOR TO THE TESLA ELECTRIC
COMPANY, OF SAME PLACE.

纽约州纽约市的尼古拉·特斯拉将该专利权转让给纽约市的特斯拉电气公司

SPECIFICATION forming part of Letters Patent No. 416,194, dated December 3, 1889.

Application filed May 20, 1889. Serial No. 311,418. (No model.)

该说明书形成了颁发于 1889 年 12 月 3 日编号为 416,194 的专利证书的一部分。

申请于 1889 年 5 月 20 日提交。序列号为 311,418。(没有模型)

To all whom it may concern:

致所有相关人士:

Be it known that I, NIKOLA TESLA, a subject of the Emperor of Austria, from Smiljan, Lika, border country of Austria-Hungary, residing at New York, in the county and State of New York, have invented certain new and useful Improvements in Electro-Magnetic Motors, of which the following is a specification, reference being had to the accompanying drawings.

众所周知,我、尼古拉·特斯拉、一位奥匈帝国的臣民,来自奥匈帝国边境地区的利卡县的史密里安村,现在居住在纽约州纽约郡纽约市,在电磁电动机方面已经发明了某些新的和有用的改进,以下是该发明一个说明书,必须参考随附的图纸,它已形成了该说明书的一部分。

This invention relates to the alternating-current electro-magnetic motors invented by me, in which a progressive shifting or rotation of the poles or points of maximum magnetic effect is produced by the action of the alternating currents.

本发明涉及由我发明的交流电磁电动机,其中通过交流电流的作用产生磁极或最大磁效应点的渐进转移或旋转。

These motors I have constructed in a great variety of ways. As instances, I have built motors with two or more energizing-circuits, which I connected up with corresponding circuits of a generator so that the motor will be energized by alternating currents differing primarily in phase. I have also built motors with independent energizing-circuits of different electrical character or self-induction, through which I have passed an alternating current the phases of which were artificially distorted by the greater retarding effect of one circuit over another. I have also constructed other forms of motor operating by magnetic or electric lag, which it is not necessary to describe herein in detail, although my present invention is applicable thereto. In such motors I use an armature wound with a coil or coils, which is sometimes connected with the external circuit and sometimes closed upon itself, and to both forms the present invention applies. In these motors the total energy supplied to effect their operation is equal to the sum of the energies expended in the armature and the field. The power developed, however, is proportionate

to the product of these quantities. This product will be greatest when these quantities are equal; hence in constructing a motor I determine the mass of the armature and field cores and the windings of both and adapt the two so as to equalize as nearly as possible the magnetic quantities of both. In motors which have closed armature-coils this is only approximately possible, as the energy manifested in the armature is the result of inductive action from the other element; but in motors in which the coils of both armature and field are connected with the external circuit the result can be much more perfectly obtained.

我用各种各样的方法制造了这些电动机。例如，我已经制造了具有两个或更多励磁电路的电动机，我将它们与发电机的相应电路连接起来，这样电动机将由主要在相位不同的交流电供电。我还制造了具有不同电气特性或自感的独立励磁电路的电动机，通过这些电路我传递一个交流电，其相位被一个电路相对于另一个电路的更大延迟效应所人为地扭曲了。我还构建了利用磁的或电的滞后来运行的其他形式的电动机，尽管我的发明可使用于此，但这里没有必要详细描述。在这种电动机中，我使用缠绕有一个或多个线圈的电枢，该电枢有时与外部电路连接，有时自身闭合，并且本发明适用于这两种形式。在这些电动机中，为实现其运行而提供的总能量等于电枢和磁场中消耗的能量之和。然而，产生的功率与这些量的乘积成正比。当这些量相等时，这个乘积最大；因此，在构造电动机时，我确定电枢和励磁铁芯以及两者绕组的质量，并调整两者以尽可能地使两者的磁量相等。在具有闭合的电枢线圈的电动机中，这仅是近似可能的，因为电枢中表现出的能量是来自其他组件的感应作用的结果；但是在电枢线圈和磁场线圈都与外部电路连接的电动机中，可以得到更完美的结果。

In further explanation of my object let it be assumed that the energy as represented in the magnetism in the field of a given motor is ninety and that of the armature ten.

在进一步解释我的目标时，假设给定电动机的磁场中的磁场能量为 90，电枢的能量为 10。

The sum of these quantities, which represents the total energy expended in driving the motor, is one hundred; but, assuming that the motor be so constructed that the energy in the field is represented by fifty and that in the armature by fifty, the sum is still one hundred; but while in the first instance the product is nine hundred, in the second it is two thousand five hundred, and as the energy developed is in proportion to these products it is clear that those motors are the most efficient—other things being equal—in which the magnetic energies developed in the armature and field are equal. These results I obtain by using the same amount of copper or ampere turns in both elements when the cores of both are equal, or approximately so, and the same current energizes both; or in cases where the currents in one element are induced to those of the other I use in the induced coils an excess of copper over that in the primary element or conductor.

这些量的总和，代表驱动电动机所消耗的总能量，是 100；但是，假设电动机是这样构造的，磁场中的能量用 50 表示，电枢中的能量用 50 表示，总和仍然是 100；但是，虽然在第一种情况下乘积是 900，在第二种情况下乘积是 2500，因为产生的能量与这些乘积成正比，很明显，这些电动机是最有效的——其他条件相同——在电枢和磁场中产生的磁能相等。这些结果是我通过在两个组件中使用相同数量的铜或安培匝数获得的，当两者的铁芯相等或近似相等时，相同的电流励磁两者；或者在一个组件中的电流被用来感应出其他组件中的那些电流的情况下，我在感应线圈中使用的铜比初级组件或初级导体中的铜过量。

While I know of no way of illustrating this invention by a drawing such as will meet the formal requirements of an application for patent, I have appended for convenience a conventional figure of a motor such as I employ. I would state, however, that I believe that with the problem before him which I have herein stated, and the solution which I have proposed, anyone skilled in the art will be able to carry out and apply this invention without difficulty.

虽然我不知道如何通过符合专利申请的形式要求的图纸来说明本发明,但为了方便起见,我还是附上了我所使用的电动机的常规图。然而,我要声明的是,我相信,对于我在此陈述的摆在他面前的问题,以及我提出的解决方案,本领域的任何技术人员将能够毫无困难地实施和应用本发明。

Generally speaking, if the mass of the cores of armature and field be equal, the amount of copper or ampere turns of the energizing-coils on both should also be equal; but these conditions will be modified in well-understood ways in different forms of machine. It will be understood that these results are most advantageous when existing under the conditions presented when the motor is running with its normal load, and in carrying out the invention this fact should be taken into consideration.

一般来说,如果电枢铁芯和励磁铁芯的质量相等,则两者上的励磁线圈的铜匝数或安培匝数也应该相等;但是这些条件将在不同形式的机器中以众所周知的方式被修改。可以理解的是,如果电动机以其正常负载运行,当提出过的条件出现时,这些结果是最有优势的,并且在实施本发明时,应该考虑这一事实。

Referring to the drawing, A is the field-magnet, B the armature, C the field-coils, and D the armature-coils, of the motor.

参照附图, A 是电动机的励磁磁铁, B 是电枢, C 是励磁线圈, D 是电枢线圈。

The motors described in this application, except as to the features specifically pointed out in the claims, are described and claimed in prior patents granted to and applications filed by me, and are not herein claimed.

本申请中描述的电动机,除主张要求中特别指出的特征外,均在先前授予我的专利和先前我提交的申请中进行了描述和主张,在此不予要求主张。

What I claim is—

我主张的是—

1. An electro-magnetic motor having field and armature magnets of equal strength or magnetic quantity when energized by a given current, as set forth.

1、一种电磁电动机,当被给定电流励磁时,拥有相等强度或磁量的场磁体和电枢磁体,如前所述。

2. In an alternating-current motor, the combination, with field and armature cores of equal mass, of

energizing-coils containing equal amounts of copper, as herein set forth.

2、在一个交流电动机中，存在一个组合，包括相同质量的励磁铁芯和电枢铁芯、以及含有等量铜的励磁线圈，如本文所述。

NIKOLA TESLA.

尼古拉·特斯拉

Witnesses:

ROBT. F. GAYLORD,

FRANK E. HARTLEY.

见证人:

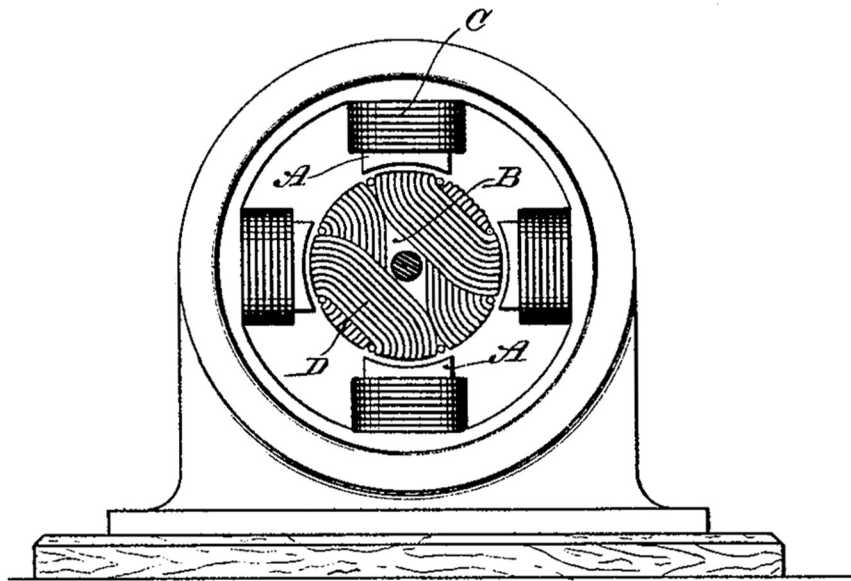
罗伯特·F·盖洛德、弗兰克·E·哈特利。

(No Model.)

N. TESLA.
ELECTRIC MOTOR.

No. 416,194.

Patented Dec. 3, 1889.



Witnesses:
Raphael Netter
Robert F. Gaylord

Inventor
Nikola Tesla
By
Duncan, Curtis & Page
Attorneys.

ELECTRO-MAGNETIC MOTOR.

电磁电动机

NIKOLA TESLA, OF NEW YORK, N. Y., ASSIGNOR TO THE TESLA ELECTRIC
COMPANY, OF SAME PLACE.

纽约州纽约市的尼古拉·特斯拉将专利权转让给纽约市的特斯拉电气公司

SPECIFICATION forming part of Letters Patent No. 416,195, dated December 3, 1889.

Application filed May 20, 1889. Serial No. 311,419. (No model.)

该说明书形成了颁发于 1889 年 12 月 3 日编号为 416,195 的专利证书的一部分。

申请于 1889 年 5 月 20 日提交。序列号为 311,419。(没有模型)

To all whom it may concern:

致所有相关人士:

Be it known that I, NIKOLA TESLA, a subject of the Emperor of Austria, from Smiljan, Lika, border country of Austria-Hungary, residing at New York, in the county and State of New York, have invented certain new and useful Improvements in Electro-Magnetic Motors, of which the following is a specification, reference being had to the drawings accompanying and forming a part of the same.

众所周知，我、尼古拉·特斯拉、一位奥匈帝国的臣民，来自奥匈帝国边境地区的利卡县的史密里安村，现在居住在纽约州纽约郡纽约市，在电磁电动机方面已经发明了某种新的和有用的改进，以下是该发明一个说明书，必须参考随附的图纸，它已形成该说明书的一部分。

This invention relates to that form of alternating-current motor invented by me, in which there are two or more energizing-circuits through which alternating currents differing in phase are caused to pass. I have in prior patents and applications shown various forms or types of this motor—first, motors having two or more energizing-circuits of the same electrical character, and in the operation of which the currents used differ primarily in phase; second, motors with a plurality of energizing-circuits of different electrical character, in or by means of which the difference of phase is produced artificially, and, third, motors with a plurality of energizing-circuits, the currents in one being induced from currents in another. I shall hereinafter show the application of my present invention to these several types. Considering the structural and operative conditions of any one of them—as, for example, that first-named—the armature which is mounted to rotate in obedience to the co-operative influence or action of the energizing-circuits has coils wound upon it which are closed upon themselves and in which currents are induced by the energizing-currents with the object and result of energizing the armature-core; but under any such conditions as must exist in these motors it is obvious that a certain time must elapse between the manifestations of an energizing-current impulse in the field-coils, and the corresponding magnetic state or phase in the armature established by the current induced thereby; consequently a given magnetic influence or effect in the field which is the

direct result of a primary-current impulse will have become more or less weakened or lost before the corresponding effect in the armature indirectly produced has reached its maximum. This is a condition unfavorable to efficient working in certain cases—as, for instance, when the progress of the resultant poles or points of maximum attraction is very great, or when a very high number of alternations is employed—for it is apparent that a stronger tendency to rotation will be maintained if the maximum magnetic attractions or conditions in both armature and field coincide, the energy developed by a motor being measured by the product of the magnetic quantities of the armature and field.

本发明涉及由我发明的那种形式的交流电动机，该电动机中有两个或多个励磁电路，相位不同的交流电通过这些电路。我在以前的专利和申请中展示了这种电动机的各种形式或类型——首先，电动机具有两个或多个相同电气特性的励磁电路，并且在运行中所使用的电流主要在相位上不同；第二，具有不同电气特性的多个励磁电路的电动机，在这些电路中或通过这些人地产生相位差，第三，具有多个励磁电路的电动机，一个电路中的电流是由另一个电路中的电流感应产生的。下面我将展示我的本发明对这几种类型的应用。考虑到它们中的任何一个的结构和运行条件——例如，第一个提到的——电枢被安装成服从励磁电路的协作的影响或作用而旋转，线圈被缠绕在电枢上，且自身闭合，并且其中电流由励磁电流感应产生，目的和结果是励磁电枢铁芯；但在这些电动机中必须存在的任何条件下，很明显，励磁线圈中一个励磁电流脉冲的出现与电枢中由感应电流建立的相应磁状态或相位之间必须经过一定的时间；因此，在电枢中间接产生的相应效应达到其最大值之前，由初级电流脉冲直接导致的磁场中的给定磁影响或效应将或多或少地减弱或消失。在某些情况下，这是一种不利于有效工作的条件——例如，当合成磁极或最大吸引点的前进非常大时，或者当采用一个非常高数量的交替时——因为很明显，如果电枢和磁场中的最大磁吸引力或磁条件实时重合，则将保持更强的旋转趋势，电动机产生的能量由电枢和磁场的磁量的乘积来测量。

The object, therefore, in this invention is to so construct or organize these motors that the maxima of the magnetic effects of the two elements—the armature and field—shall more nearly coincide. This I accomplish in various ways, which I may best explain by reference to the drawings, in which various plans for accomplishing the desired results are illustrated.

因此，本发明的目的是这样构建或组织这些电动机，使得两个组件——电枢和磁场——的磁效应的最大值点更加几乎实时重合。我以各种方式实现了这一点，我可以通过参考附图来最好地解释这一点，附图中展示了用于实现期望结果的各种方案。

Figure 1: This is a diagrammatic illustration of a motor system such as I have described in my prior patents, and in which the alternating currents proceed from independent sources and differ primarily in phase.

图 1：这是一个电动机系统的示意图，例如我在以前的专利中描述的电动机系统，其中交流电来自独立的电源，主要是相位不同。

A designates the field-magnet or magnetic frame of the motor; B B, oppositely-located pole-pieces adapted to receive the coils of one energizing-circuit; and C C, similar pole-pieces for the coils of the other energizing-circuit. These circuits are designated, respectively, by D E, the conductor D" forming

a common return to the generator G. Between these poles is mounted an armature—for example, a ring or annular armature, wound with a series of coils F, forming a closed circuit or circuits. The action or operation of a motor thus constructed is now well understood. It will be observed, however, that the magnetism of poles B, for example, established by a current-impulse in the coils thereon, precedes the magnetic effect set up in the armature by the induced current in coils F. Consequently the mutual attraction between the armature and field-poles is considerably reduced. The same conditions will be found to exist if, instead of assuming the poles B or C as acting independently, we regard the ideal resultant of both acting together, which is the real condition. To remedy this, I construct the motor-field with secondary poles B' C', which are situated between the others. These pole-pieces I wind with coils D' E', the former in derivation to the coils D, the latter to coils E. The main or primary coils D and E are wound for a different self-induction from that of the coils D' and E', the relations being so fixed that if the currents in D and E differ, for example, by a quarter-phase, the currents in each secondary coil, as D' E', will differ from those in its appropriate primary D or E by, say, forty-five degrees, or one-eighth of a period.

A 表示电动机的磁场或磁框架；B B 是适于接收一个励磁电路的线圈的径向相对定位的极靴；C C 是用于另一个励磁电路的线圈的类似极靴。这些电路分别用 D E 表示，导线 D" 形成了到达发电机 G 的一条公共回路。在这些磁极之间安装有一个电枢，例如，一个环形电枢，上面缠绕有一连串的线圈 F，形成了闭合电路。这样构建的电动机的动作或运行现在已经很好理解了。然而，可以观察到，例如由线圈中的电流脉冲建立的磁极 B 的磁性先于由线圈 F 中的感应电流在电枢中建立的磁效应。因此，电枢和场磁极之间的相互吸引大大减少。如果我们不假设极点 B 或 C 独立地起作用，而是将两者共同作用的结果视为真实条件，则会发现存在相同的条件。为了补救这一点，我用位于其他磁极之间的次级磁极 B' C' 来构建电动机磁场。这些极靴我用线圈 D' E' 缠绕，前者间接连接（通过其他线圈连接）到线圈 D，后者连接到线圈 E。主线圈或初级线圈 D 和 E 与线圈 D' 和 E' 的自感不同，它们之间的关系是这样确定的，即如果 D 和 E 中的电流相差四分之一相位，则每个次级线圈 D' E' 中的电流将与其相应的初级线圈 D 或 E 中的电流相差 45 度或八分之一周期。

I explain the action of this motor as follows: Assuming that an impulse or alternation in circuit or branch E is just beginning while in the branch D it is just falling from maximum, the conditions of a quarter-phase difference. The ideal resultant of the attractive forces of the two sets of poles B C therefore may be considered as progressing from poles B to poles C while the impulse in E is rising to maximum and that in D is falling to zero or minimum. The polarity set up in the armature, however, lags behind the manifestations of field magnetism, and hence the maximum points of attraction in armature and field, instead of coinciding, are angularly displaced. This effect is counteracted by the supplemental poles B' C'. The magnetic phases of these poles succeed those of poles B C by the same, or nearly the same, period of time as elapses between the effect of the poles B C and the corresponding induced effect in the armature; hence the magnetic conditions of poles B' C' and of the armature more nearly coincide and a better result is obtained. As poles B' C' act in conjunction with the poles in the armature established by poles B C, so in turn poles C B act similarly with the poles set up by B' C', respectively. Under such conditions the retardation of the magnetic effect of the armature and that of the secondary poles will bring the maximum of the two more nearly into coincidence and a correspondingly-stronger torque or magnetic attraction secured.

我解释这个电动机的动作如下：假设电路或支路 E 中的一个脉冲或交替刚刚开始四分之一

相位差的条件，而在支路 D 中它刚刚从最大值下降。当 E 中的脉冲上升到最大值，而 D 中的脉冲下降到零或最小值时，两组磁极 B C 的吸引力的理想合力因此可以被认为从磁极 B 前进到磁极 C。然而，电枢中建立的极性滞后于磁场磁性的出现，因此电枢和磁场中的最大吸引点不是重合的，而是有角度位移的。这种效应被增补的极点 B' C' 抵消了。这些磁极的磁相位以一定的时间间隔承继在磁极 B C 的磁相位之后，该时间间隔是与磁极 B C 的效应和电枢中相应的感应效应之间的时间间隔相同或者几乎相同；因此，磁极 B' C' 的磁性条件和电枢的磁性条件更接近实时重合，并且获得了一个更好的结果。由于磁极 B' C' 与由磁极 B C 在电枢中建立的磁极共同作用，因此反过来磁极 C B 分别与由磁极 B' C' 建立的磁极产生相似的作用。在这种条件下，电枢的磁效应的延迟和次级磁极的磁效应的延迟将使两者中的最大值带到更接近实时重合，并确保相应更强的转矩或磁引力。

In such a disposition as is shown in Fig. 1 it will be observed that as the adjacent pole-pieces of either circuit are of like polarity they will have a certain weakening effect upon one another. I therefore prefer to remove the secondary poles from the direct influence of the others. This I may do by constructing a motor with two independent sets of fields, and with either one or two armatures electrically connected, or by using two armatures and one field. These modifications will be illustrated hereinafter.

在如图 1 所示的这种布置中，可以观察到，由于任一电路的相邻极靴具有相同的极性，它们将对彼此产生一定的削弱作用。因此，我更喜欢将次级磁极从其他磁极的直接影响中移除。为此，我可以构建一个电动机，它具有两组独立磁场和一个或两个被电连接的电枢，或者使用两个电枢和一个磁场。这些修改将在下文中说明。

Fig. 2 is a diagrammatic illustration of a motor and system in which the difference of phase is artificially produced. There are two coils D D in one branch and two coils E E in the other branch of the main circuit from the generator G. These two circuits or branches are of different self-induction, one, as D, being higher than the other. For convenience I have indicated this by making coils D much larger than coils E. By reason of this difference in the electrical character of the two circuits the phases of current in one are retarded to a greater extent than the other. Let this difference be thirty degrees. A motor thus constructed will rotate under the action of an alternating current; but as happens in the case previously described the corresponding magnetic effects of the armature and field do not coincide owing to the time that elapses between a given magnetic effect in the armature and the condition of the field that produces it. I therefore employ the secondary or supplemental poles B' C'. There being thirty degrees difference of phase between the currents in coils D E, the magnetic effects of poles B' C' should correspond to that produced by a current differing from the current in coils D or E by fifteen degrees. This I may accomplish by winding each supplemental pole B' C' with two coils H H'. The coils H are included in a derived circuit having the same self-induction as circuit D, and coils H' in a circuit having the same self-induction as circuit E, so that if these circuits differ by thirty degrees the magnetism of poles B' C' will correspond to that produced by a current differing from that in either D or E by fifteen degrees. This is true in all other cases. For example, if in Fig. 1 the coils D' E' be replaced by the coils H H' included in derived circuits, the magnetism of the poles B' C' will correspond in effect or phase, if it may be so termed, to that produced by a current differing from that in either circuit D or E by forty-five degrees, or one-eighth of a period.

图 2 是一个电动机和一个系统的示意图，其中相位差是人工产生的。发电机 G 的主电路的

一个支路中有两个线圈 D D，另一个支路中有两个线圈 E E。这两个电路或分支具有不同的自感，如 D，比另一个高。为了方便起见，我把线圈 D 做得比线圈 E 大得多。由于两个电路电气特性的这种差异，一个电路中的电流相位比另一个电路延迟更大。假设这个差值是三十度。这样构造的电动机将在交流电的作用下旋转；但是如在前面描述的情况中发生的那样，由于电枢中的一个给定磁效应和产生该磁效应的磁场条件之间经过的时间，电枢的相应磁效应和磁场的相应磁效应不是实时重合。因此，我采用辅助或补充极点 B' C'。线圈 D E 中的电流相差 30 度，磁极 B' C' 的磁效应应该与线圈 D 或 E 中的电流相差 15 度的电流所产生的磁效应相对应。这可以通过用两个线圈 H H' 缠绕每个补充磁极 B' C' 来实现。线圈 H 被包含在具有与电路 D 相同的自感的一个间接电路中，线圈 H' 被包含在具有与电路 E 相同的自感的一个电路中，因此如果这些电路相差 30 度，则磁极 B' C' 的磁性将对应于与 D 或 E 中的磁性相差 15 度的电流所产生的磁性。在所有其他情况下都是如此。例如，如果在图 1 中线圈 D' E' 由被包含在间接电路中的线圈 H H' 所代替，则磁极 B' C' 的磁性将在效果或相位，如果可以这样命名的话，将对应于与电路 D 或 E 中的电流相差 45 度或八分之一周期的电流所产生的磁性。

This invention as applied to a derived-circuit motor is illustrated in Figs. 3 and 4. The former is an end view of the motor with the armature in section and a diagram of connections, and Fig 4 a vertical section through the field. These figures are also drawn to show one of the dispositions of two fields that may be adopted in carrying out the invention. The poles B B C C are in one field, the remaining poles in the other. The former are wound with primary coils I J and secondary coils I' J', the latter with coils K L. The primary coils I J are in derived circuits, between which, by reason of their different self-induction, there is a difference of phase, say, of thirty degrees. The coils I' K are in circuit with one another, as also are coils J' L, and there should be a difference of phase between the currents in coils K and L and their corresponding primaries of, say, fifteen degrees. If the poles B C are at right angles, the armature-coils should be connected directly across, or a single armature-core wound from end to end may be used; but if the poles B C be in line there should be an angular displacement of the armature-coils, as will be well understood.

图 3 和图 4 展示了应用于间接电路电动机的本发明。前者是带有电枢的电动机的端视图和连接示意图，图 4 是穿过磁场的垂直截面图。这些图也被绘制来显示在实施本发明时可以采用的两个磁场的布置之一。磁极 B B C C 在一个磁场中，其余的磁极在另一个磁场中。前者缠绕有初级线圈 I J 和次级线圈 I' J'，后者缠绕有线圈 K L。初级线圈 I J 在间接电路中，由于它们不同的自感，在它们之间存在一个相位差，比如说 30 度。线圈 I' K 在电路中彼此相连，线圈 J' L 也是如此，并且线圈 K 和 L 中的电流和它们相应的初级线圈之间应该有一个相位差，比如说 15 度。如果磁极 B C 成直角，电枢线圈应直接交叉连接，或者可以使用从一端缠绕到另一端的单个电枢铁芯；但是如果磁极 B C 在一条直线上，电枢线圈就会有角位移，这是很容易理解的。

The operation will be understood from the foregoing. The maximum magnetic condition of a pair of poles, as B' B', coincides closely with the maximum effect in the armature, which lags behind the corresponding condition in poles B B.

从前面的描述中可以理解该操作。一对磁极（如 B' B'）的最大磁性条件，与电枢中的最大效应接近实时重合，电枢中的最大效应滞后于磁极 B B 中的相应条件。

There are many other ways of carrying out this invention, but they all involve the same broad principle of construction and operation.

有许多其他方式来实现本发明，但是它们都涉及相同的广泛的构建和运行的原理。

In using expressions herein to indicate a coincidence of the magnetic phases or effects in one set of field-magnets with those set up in the armature by the other I refer only to approximate results; but this of course will be understood.

在使用此处的表达来指出一组场磁体中的磁相位或磁效应与另一组场磁体在电枢中建立的磁相位或磁效应实时重合时，我仅指近似的结果；但这当然会被理解。

What I claim is—

我主张的是—

1. In an alternating-current motor, the combination, with an armature wound with closed coils, of main and supplemental field magnets or poles, one set of which is adapted to exhibit their maximum magnetic effect simultaneously with that set up in the armature by the action of the other, as set forth.

1、在一个交流电动机中，主磁场磁体或磁极与补充磁场磁体或磁极的组合，电枢上缠绕有闭合线圈，其中一组磁体或磁极适合于通过另一组磁体或磁极的作用在电枢中产生最大磁效应，如上所述。

2. In an electro-magnetic motor, the combination, with an armature, of a plurality of field or energizing coils included, respectively, in main circuits adapted to produce a given difference of phase and supplemental or secondary circuits adapted to produce an intermediate difference of phase, as set forth.

2、在一个电磁电动机中，多个磁场或励磁线圈与电枢的组合，分别被包含在适于产生给定相位差的主电路和适于产生中间相位差的补充电路或辅助电路，如前所述。

NIKOLA TESLA.

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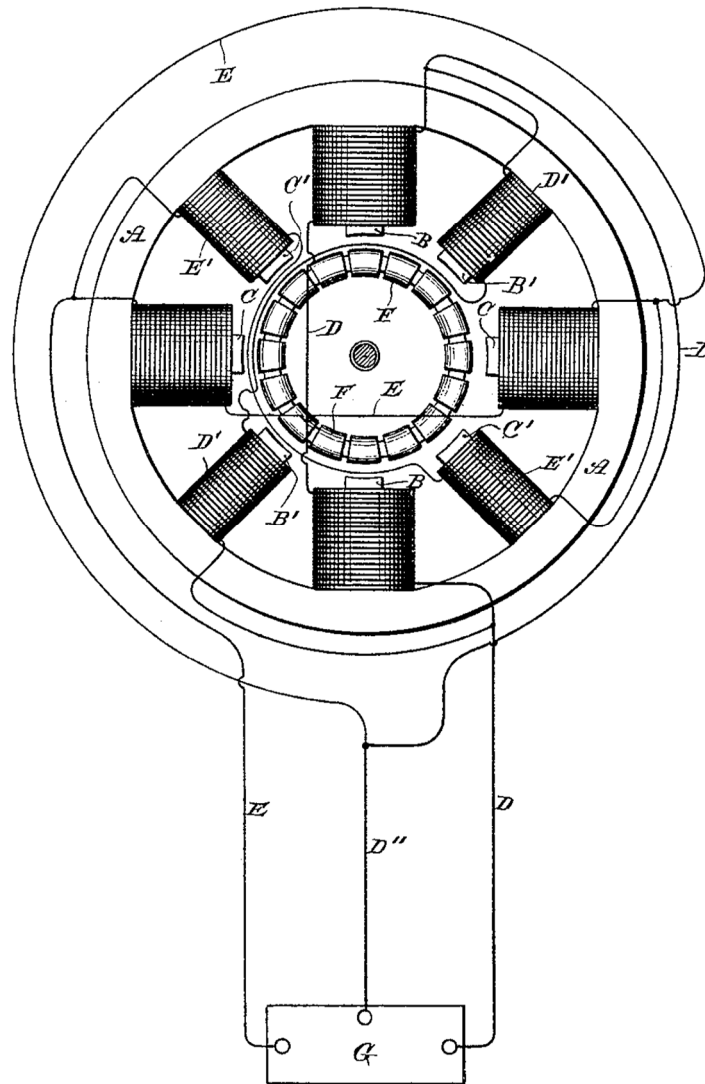
R. J. 斯托尼、约翰·吉莱斯皮。

N. TESLA.
ELECTRO MAGNETIC MOTOR.

No. 416,195.

Patented Dec. 3, 1889.

Fig. 1



Witnesses:
Raphaël Netter
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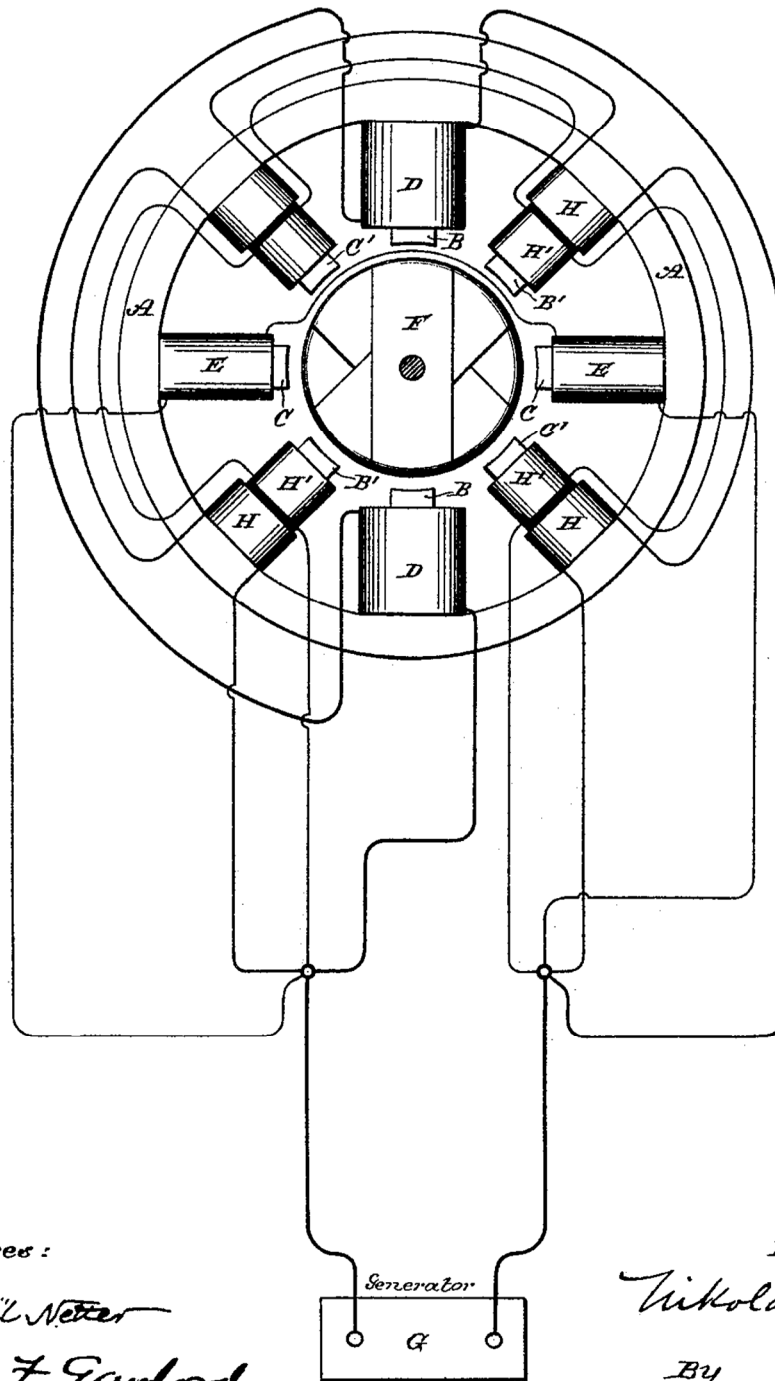
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N. TESLA.
ELECTRO MAGNETIC MOTOR.

No. 416,195.

Patented Dec. 3, 1889.

Fig. 2



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N. TESLA.
ELECTRO MAGNETIC MOTOR.

No. 416,195.

Patented Dec. 3, 1889.

Fig. 3

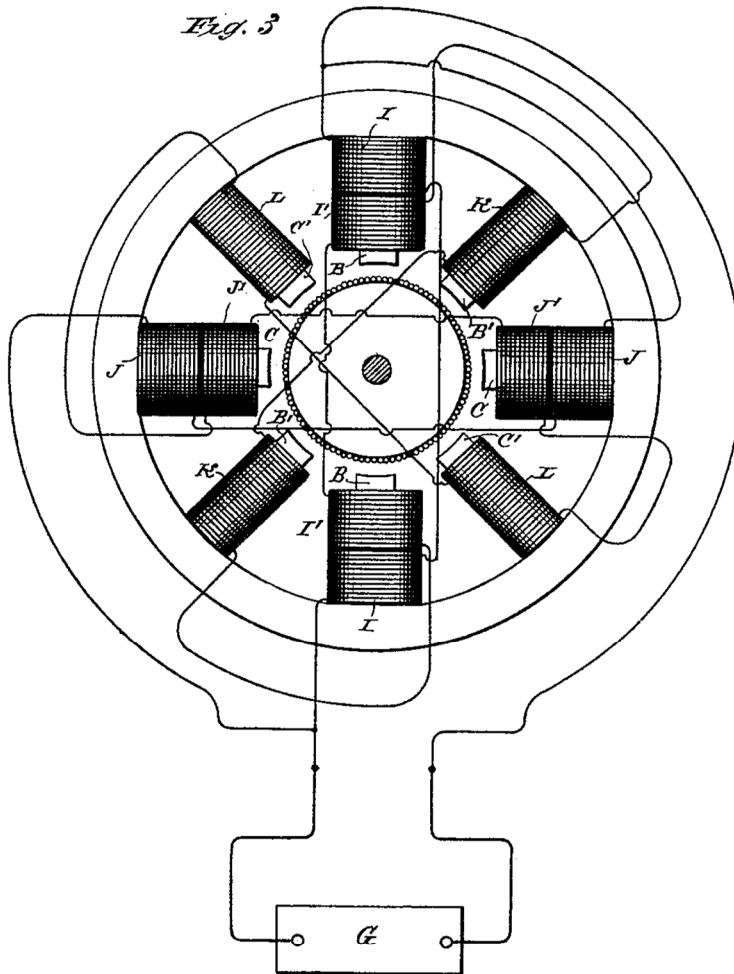
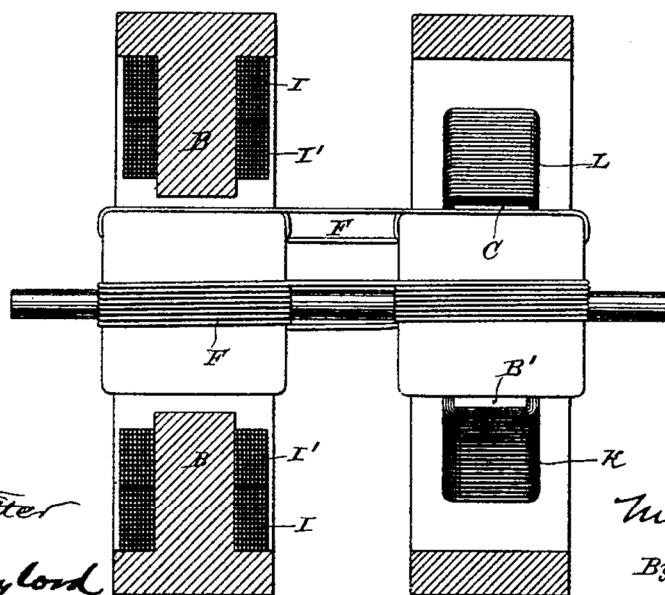


Fig. 4



Witnesses:
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ARMATURE FOR ELECTRIC MACHINES.

用于电动机的电枢

ALBERT SCHMID, OF ALLEGHENY, AND NIKOLA TESLA, OF PITTSBURGH,
ASSIGNORS TO THE WESTINGHOUSE ELECTRIC COMPANY, OF PITTSBURGH,
PENNSYLVANIA.

阿勒格尼市的艾伯特·施密德和匹兹堡市的尼古拉·特斯拉将专利权转让给
宾夕法尼亚州匹兹堡市西屋电气公司。

SPECIFICATION forming part of Letters Patent No. 417,794, dated December 24, 1889.

Application filed June 28, 1889. Serial No. 315,937. (No model.)

该说明书形成了颁发于 1889 年 12 月 24 日编号为 417,794 的专利证书的一部分。

申请于 1889 年 6 月 28 日提交。序列号为 315,937。(没有模型)

To all whom it may concern:

致所有相关人士:

Be it known that we, ALBERT SCHMID and NIKOLA TESLA, citizens, respectively, of the Republic of Switzerland and Smiljan, Lika, border country of Austria-Hungary, now residing in Allegheny and Pittsburgh, both in the country of Allegheny and State of Pennsylvania, have invented a certain new and useful Improvement in Armatures for Electric Machines, (Case No. 310,) of which the following is a specification.

众所周知，我们、艾伯特·施密德和尼古拉·特斯拉，分别是来自瑞士共和国和奥匈帝国边境地区的利卡县的史密里安村的两位公民，现分别居住在宾夕法尼亚州阿勒格尼郡的阿勒格尼市和匹兹堡市，在用于电动机的电枢方面已经发明了某种新的和有用的改进（备案编号 310），以下是该发明一个说明书。

The invention relates to the construction of armatures for electric generators and motors, and the object is to provide an electrically efficient armature, the construction of which is simple and economical, and in which the coils of insulated conducting wire or ribbon may be conveniently wound or formed into bobbins so located with reference to the body of the armature as to afford as good results as possible.

本发明涉及用于发电机和电动机的电枢的结构，并且目的是提供一种电效率高的电枢，它的构建简单且经济，并且其中被绝缘的导线或导电带制成的线圈可以方便地缠绕或形成绕线筒，该绕线筒参考电枢主体定位以提供尽可能好的结果。

For certain purposes it is desirable to construct the armatures of electric generators and motors with their cores of magnetizable material projecting through the coils into close proximity to the field-magnet poles. When armatures are constructed in this manner, some means are necessary for holding the coils in position and preventing them from being thrown out by centrifugal force.

出于某些目的，希望构建发电机和电动机的电枢，使它们的可磁化材料制成的铁芯穿过线圈突出到场磁体磁极附近。当以这种方式构造电枢时，需要一些工具来将线圈固定在适当的位置，并防止它们被离心力甩出。

This invention aims to provide such means in an armature having polar projections, and also to form an armature in such manner as to expose a large area of core-surface to the field-magnet poles.

本发明旨在在具有极性突起的一个电枢中提供这样的装置，并且还以这样的方式形成电枢，以便将大面积的铁芯表面暴露给场磁体磁极。

The invention consists, in general terms, in forming an armature-core which is preferably built up of laminae of magnetizable material insulated from each other, with diverging slots or openings for receiving the armature wire or ribbon, which slots are connected with the exterior of the armature by openings through which the wire may be laid in the slots, and in placing the wire in such slots in the proper manner.

概括地说，本发明包括形成一个电枢铁芯，该电枢铁芯最好地由彼此绝缘的可磁化材料制成的叠片构成，具有用于接受电枢导线或电枢带的分叉槽或开口，该槽通过开口与电枢的外部连接，通过这些开口可以将导线铺设在槽中，并且以适当的方式将导线放置在这些槽中。

We are aware of the United States Patents No. 327,797, granted to Immisch, and No. 292,077, granted to Wenstrom, and the British patent of Coerper, No. 9,013 of 1887, and do not claim the construction shown and described therein.

我们知道授予伊米施的美国专利第 327,797 号和授予温斯特伦的第 292,077 号，以及 1887 年授予库珀的英国专利第 9,013 号，并且没有要求主张其中所示和所述的结构。

The invention will be described more particularly in connection with the accompanying drawings, in which—

将结合附图更具体地描述本发明，其中——

Figure 1 is an end view, partly in section, of an armature embodying the features of the invention, and Fig. 2 is a plan of the armature.

图 1 是体现本发明特征的电枢的端视图，部分是截面形式，图 2 是电枢的平面图。

Referring to the figures, F F indicate field-magnet poles, and A represents the body or core of an armature composed, in this instance, of laminae of magnetizable material built up in any suitable manner, the laminae being preferably separated by intervening strata of insulating material. The individual plates or laminae are constructed with radial openings c, extending a short distance from the surface, and with slots or openings b, which extend in different directions from the openings c. The slots diverge from each other at such angles as to cause the two slots upon the opposite sides of each web e thus formed to lie in the same chord of the circle of the armature. The plates may also be stamped or formed with openings G to remove the unnecessary metal. After the plates are formed they are laid up in the proper

manner to form the entire armature-core, the slots b being placed opposite each other to form continuous openings through the entire length of the armature. These openings may be lined by pockets h of insulating material—such, for instance, as vulcanized fiber—and the wires are then wound into the slots from the openings c and around the respective webs e. Winding-clips k may be placed at the respective ends of the armature opposite each web e to hold the wires in the proper positions as they are wound in the slots and down upon the armature ends.

参考附图，FF 表示场磁体磁极，A 表示电枢的主体或铁芯，在这种情况下，电枢是由按照任何合适的方式构建的可磁化材料的叠片组成，叠片最好由绝缘材料制成的介入层分开。各个板或叠片被构建有从表面延伸一小段距离的辐射状开口 c，以及从开口 c 沿不同方向延伸的槽或开口 b，槽以这样的角度彼此分叉，使得这样形成的每个腹板 e 的相对侧上的两个狭槽位于电枢圆周的同一弦上。这些板也可以被冲压或形成有开口 G，以去除不必要的金属。在板形成之后，它们以适当的方式叠放以形成整个电枢铁芯，槽 b 彼此相对布置以形成贯穿电枢整个长度的连续开口。这些开口可以衬有绝缘材料袋 h，例如硬化纸板（硫化纤维），然后将导线从开口 c 缠绕到槽中，并围绕相应的腹板 e。绕组夹 k 可以放置在电枢的与每个腹板 e 相对的相应端部，这样可以在电线缠绕在槽中并向下缠绕在电枢端部的同时将电线保持在适当的位置。

The wires having been wound into their proper positions, they may be held more securely in position by means of blocks K of non-magnetic material, placed at intervals or extending through the entire slots or openings c and projecting into the slots b.

导线已经被缠绕到它们的适当位置，它们可以通过非磁性材料的块 K 更牢固地保持到位，这些块 K 间隔放置或者延伸穿过整个槽或开口 c 并伸入槽 b 中。

An armature constructed in the manner described is found to be very efficient in its operations and at the same time simple in its construction.

发现以所述方式构造的电枢在其运行中非常有效，同时其结构简单。

The connections between the armature-coils and the conductors or collecting-plates may be made in any usual well-known manner, according to the purposes desired to be served.

电枢线圈和导体或集电板之间的连接可以根据所要服务的目的以任何通常熟知的方式进行。

We claim as our invention is—

我们主张我们的发明是—

1. A core for electrical machines, composed of plates of magnetizable material separated by insulation, said plates having diverging slots for receiving the armature-conductors and an opening to the exterior of the plate at the origin of the diverging slots.

1、一种用于电动机的铁芯，包括由绝缘材料隔开的可磁化材料板，所述板具有用于容纳电枢导体的分叉槽和在分叉槽起点处通向板外部的开口。

2. A core-plate for electrical machines, stamped with diverging slots at intervals near its periphery and an opening to the periphery at the angle formed by each two diverging slots.

2、一种用于电动机的铁芯板，在其外周附近间隔地冲压有分叉槽，并且在由每两个分叉槽形成的角处向外周开口。

3. A core for electrical machines, composed of plates of magnetizable material separated by insulation, said plates having diverging slots for receiving the armature-conductors and an opening to the exterior of the plate at the origin of the diverging slots, the width of such openings being approximately equal to the width of the slot.

3、一种用于电动机的铁芯，包括由绝缘材料隔开的可磁化材料板，所述板具有用于容纳电枢导体的分叉槽和在分叉槽起点处通向板外部的开口，这种开口的宽度大约等于槽的宽度。

4. An armature-core for electric machines, consisting of plates of magnetizable material separated by insulation, having radial openings at intervals, slots diverging from said openings for receiving armature-coils, and winding blocks or clips at the ends of the core.

4、一种用于电动机的电枢铁芯，包括由绝缘材料隔开的可磁化材料板，具有间隔分布的辐射状开口、从所述开口分叉的用于接受电枢线圈的槽，以及位于铁芯端部的绕组块或线夹。

5. An armature-core for electrical apparatus, composed of plates of magnetizable material separated by insulation and having radial openings at intervals, slots extending in opposite directions from said openings for receiving wires, and insulating-linings for said slots.

5、一种用于电气装置的电枢铁芯，包括由绝缘材料隔开的可磁化材料板，并具有间隔分布的径向开口、从所述开口沿相反方向延伸的用于接受导线的槽以及用于所述槽的绝缘衬里。

6. An armature for electric machines, consisting of a laminated core formed with diverging slots for receiving the wires, said slots leaving intervening webs, and coils of wire wound in said slots.

6、一种用于电动机的电枢，包括形成有用于接受导线的分叉槽的一个叠片铁芯、所述槽留有介于之间的腹板、以及缠绕在所述槽中的线圈。

7. An armature for electric machines, consisting of a laminated core formed with diverging slots for receiving the wires, said slots leaving intervening webs, coils of wire wound in said slots, and non-magnetizable material closing the openings of the adjacent slots outside the wires, substantially as described.

7、一种用于电动机的电枢，包括形成有用于接收导线的分叉槽的叠片铁芯、所述槽留有介于之间的腹板、缠绕在所述槽中的线圈、以及封闭导线外部的相邻槽的开口的不可磁化材料，基本如所述。

8. An armature for electric machines, consisting of a core having its outer surface continuous except for narrow longitudinal openings at intervals and having slots diverging from said openings, armature-

coils wound in said slots, and blocks or strips of non-magnetizable material closing the openings and forming with the metal of the armature a practically continuous surface.

8、一种用于电动机的电枢，包括一个除了间隔分布的窄的纵向开口外，其外表面是连续的并具有从所述开口分叉的槽的铁芯、还有缠绕在所述槽中的电枢线圈、以及封闭开口并与电枢金属形成实际上连续表面的不可磁化材料的块或条。

In testimony whereof we have hereunto subscribed our names this 25th day of June, A. D. 1889.

我们已于公元 1889 年 6 月 25 日在此签名为证。

ALBERT SCHMID.

NIKOLA TESLA.

阿尔伯特·施密德

尼古拉·特斯拉

Witnesses:

W. D. UPTGRAFF,

CHARLES A. TERRY.

见证人：

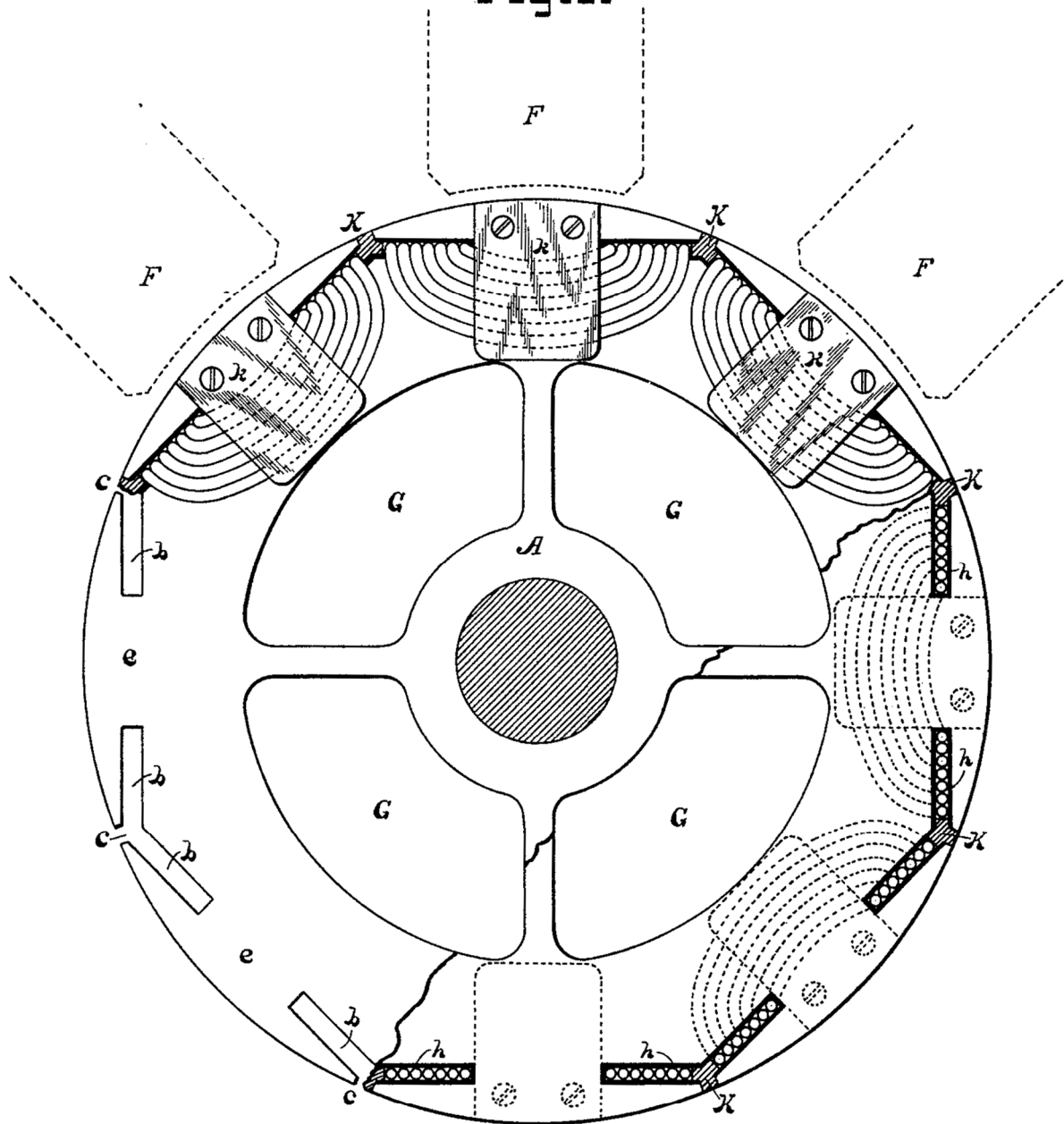
W. D.厄普德格拉夫、查尔斯·A·特里。

A. SCHMID & N. TESLA.
ARMATURE FOR ELECTRIC MACHINES.

No. 417,794.

Patented Dec. 24, 1889.

Fig. 1.



WITNESSES:

George Brown, Jr.
Wm. Smith.

INVENTORS:

Albert Schmid,
Nikola Tesla.

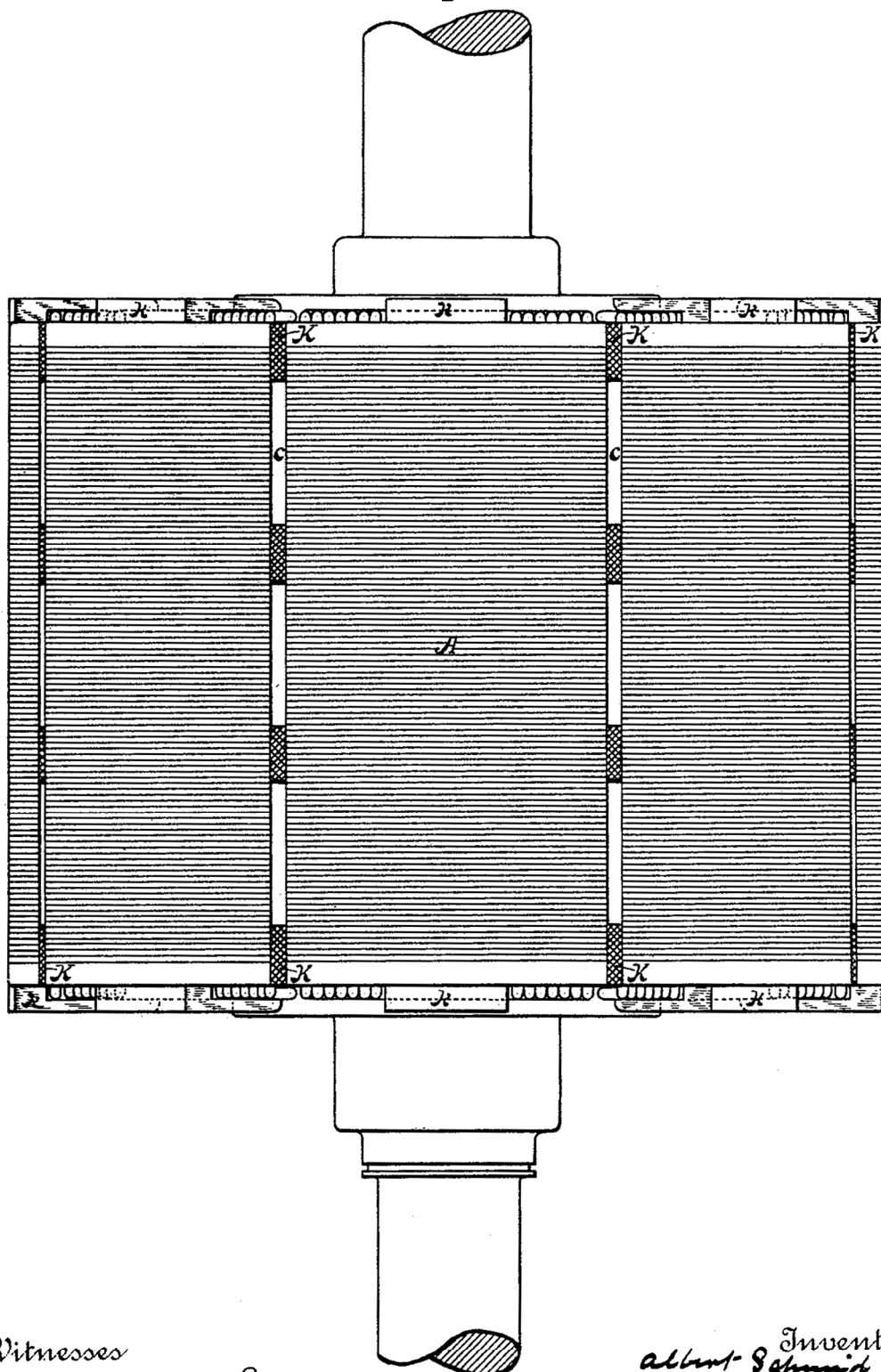
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A. SCHMID & N. TESLA.
ARMATURE FOR ELECTRIC MACHINES.

No. 417,794.

Patented Dec. 24, 1889.

Fig-2.



Witnesses
George Brown Jr.
J. M. Smith

Inventor
Albert Schmid
Nikola Tesla
By their Attorney
Charles A. Terry

ELECTRO-MAGNETIC MOTOR.

电磁电动机

NIKOLA TESLA, OF NEW YORK, N. Y., ASSIGNOR TO THE TESLA ELECTRIC
COMPANY, OF SAME PLACE.

纽约州纽约市的尼古拉·特斯拉将专利权转让给纽约市的特斯拉电气公司

SPECIFICATION forming part of Letters Patent No. 418,248, dated December 31, 1889.

Application filed May 20, 1889. Serial No. 311,420. (No model.)

该说明书形成了颁发于 1889 年 12 月 31 日编号为 418,248 的专利证书的一部分。

申请于 1889 年 5 月 20 日提交。序列号为 311,420。(没有模型)

To all whom it may concern:

致所有相关人士:

Be it known that I, NIKOLA TESLA, a subject of the Emperor of Austria-Hungary, formerly of Smiljan, Lika, border country of Austria-Hungary, but now residing at New York, in the county and State of New York, have invented certain new and useful Improvements in Methods of Operating Electro-Magnetic Motors, of which the following is a specification, reference being had to the drawing accompanying and forming a part of the same.

众所周知，我、尼古拉·特斯拉、一位奥匈帝国的臣民，来自奥匈帝国边境地区的利卡县的史密里安村，但现在居住在纽约州纽约郡纽约市，在运行电磁电动机的方法方面已经发明了某种新的和有用的改进，以下是该发明一个说明书，必须参考随附的图纸，它已形成该说明书的一部分。

In a patent granted to me April 16, 1889, No. 401,520, I have shown and described a method of operating alternating-current motors by first shifting or rotating their magnetic poles until they had reached or passed a synchronous speed and then alternating the poles, or, in other words, by transforming the motor by a change of circuit-connections from one operated by the action of two or more independent energizing-currents to a motor operated by a single current or several acting as one.

在 1889 年 4 月 16 日授予我的第 401,520 号专利中，我已经展示并描述了一种运行交流电动机的方法，首先转移或旋转它们的磁极直到它们已经达到或超过一个同步速度，然后改变磁极，或者换句话说，通过电路连接的一个改变将电动机从由两个或多个独立的励磁电流的作用来运行的电动机转变为由单个电流或几个电流作为一个电流来运行的电动机。

The present invention is a specific way of carrying out the same invention; and it consists in the following method: On the start I progressively shift the magnetic poles of one element or field of the motor by alternating currents differing in phase as passed through independent energizing-circuits and short-circuit the coils of the other element. When the motor thus started reaches or passes the limit of

speed synchronous with the generator, I connect up the coils previously short-circuited with a source of direct current and by a change of the circuit-connections produce a simple alternation of the poles. The motor then continues to run in synchronism with the generator. There are many specifically-different ways in which this may be carried out, but I have selected one for illustrating the principle. This is illustrated in the annexed drawing, which is a side view of a motor with a diagram of the circuits and devices used in the system.

本发明是实施同一发明的特定方式；并且它包括以下方法：开始时，我将不同相位的交流电通过独立的励磁电路，来逐渐改变电动机的一个组件或一个磁场的磁极，并短路其他组件的线圈。当这样启动的电动机达到或越过与发电机同步的速度限制时，我用一个直流电源连接先前被短路的线圈，并利用电路连接的一个变化产生一个简单的电极的交替。然后，电动机继续与发电机同步运行。有许多具体不同的方法可以实现这一点，但我选择了一个方法来说明这个原理。附图说明了这一点，附图是电动机的侧视图，具有系统中使用的电路和设备的示意图。

The motor shown is one of the ordinary forms, with field-cores either laminated or solid and with a cylindrical laminated armature wound, for example, with the coils A B at right angles. The shaft of the armature carries three collecting or contact rings C D E. (Shown, for better illustration, as of different diameters.)

所示电动机是一种普通形式，具有叠片或实心的励磁铁芯，以及圆柱形叠片电枢，该电枢由线圈，例如 A 和 B，以直角缠绕。电枢的轴携带三个集电环或接触环 C D E。（为了更好地说明，展示出不同的直径。）

One end of coil A connects to one ring, as C, and one end of coil B connects with ring D. The remaining ends are connected to ring E. Collecting springs or brushes F G H bear upon the rings and lead to the contacts of a switch, to be hereinafter described. The field-coils have their terminals in binding-posts K K, and may be either closed upon themselves or connected with a source of direct current L by means of a switch M. The main or controlling switch has five contacts a b c d e and two levers f g, pivoted and connected by an insulating cross-bar h, so as to move in parallelism. These levers are connected to the line-wires from a source of alternating currents N. Contact a is connected to brush G and coil B through a dead-resistance R and wire P. Contact b is connected with brush F and coil A through a self-induction coil S and wire O. Contacts c and e are connected to brushes G F, respectively, through the wires P O, and contact d is directly connected with brush H. The lever f has a widened end which may span the contacts a b. When in such position and with lever g on contact d, the alternating currents divide between the two motor-coils, and by reason of their different self-induction a difference of current-phase is obtained that starts the motor in rotation. In starting, as I have above stated, the field-coils are short-circuited.

线圈 A 的一端连接到一个环，如 C，线圈 B 的一端连接到环 D。其余两端连接到环 E。收集弹簧或电刷 F G H 倚靠在环上，并通向开关的触点，这将在下文中描述。励磁线圈的终端在接线柱 K K 上，可以自行闭合，也可以通过一个开关 M 与直流电源 L 连接。主开关或控制开关具有五个触点 a b c d e 和两个杠杆 f g，通过一个绝缘横杆 h 枢转和连接，以便平行移动。这些杠杆连接到一个交流电源 N 的导线上。触点 a 通过一个吸收电阻 R 和一条导线 P 连接到电刷 G 和线圈 B。触点 b 通过一个自感线圈 S 和一个导线 O 与电刷 F 和线圈 A 相

连。触点 c 和 c 分别通过导线 P O 与电刷 G F 相连，触点 d 直接与电刷 H 相连。杠杆 f 有一个可以跨越触点 a b 的加宽端。当在这样的位置并且杠杆 g 在触点 d 上时，交流电在两个电动机线圈之间分流，并且由于它们不同的自感，获得了启动电动机旋转的电流相位差。开始时，正如我上面所说的，励磁线圈是短路的。

When the motor has attained the desired speed, the switch is shifted to the position shown in dotted lines—that is to say, with the levers f g resting on points c e. This connects up the two armature-coils in series, and the motor will then run as a synchronous-motor. The field-coils are thrown into circuit with the direct-current source when the main switch is shifted.

当电动机达到预期的速度时，开关切换到虚线所示的位置，也就是说，杠杆 f g 停留在 c e 点上。这将两个电枢线圈串联起来，然后电动机将作为一个同步电动机运行。当主开关切换时，励磁线圈被切换到直流电源电路中。

What I claim herein as my invention is—

我在这里主张我的发明是—

1. The method of operating electro-magnetic motors, which consists in first progressively shifting or rotating the magnetic poles of one element until it has reached a synchronous speed and then alternating said poles and passing a direct current through the coils of the other element, as herein set forth.

1、运行电磁电动机的方法，包括首先逐渐转移或旋转一个组件的磁极，直到它达到同步速度，然后交替所述磁极，并使直流电通过另一个组件的线圈，如本文所述。

2. The method of operating electro-magnetic motors, which consists in short-circuiting the coils of one element, as the field-magnet, and passing through the energizing-coils of the other element, as the armature, alternating currents differing in phase, and then, when the motor has attained a given speed, passing through the field-coils a direct current and through the armature-coils alternating currents coinciding in phase.

2、运行电磁电动机的方法，包括短路一个组件（如场磁铁）的线圈，并使电流通过另一个组件（如电枢）的励磁线圈，交替不同相位的电流，然后，当电动机达到一个给定速度时，将一个直流电通过励磁线圈，并将相位一致的交流电通过不同的电枢线圈。

NIKOLA TESLA.

尼古拉·特斯拉

Witnesses:

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E. P. COFFIN.

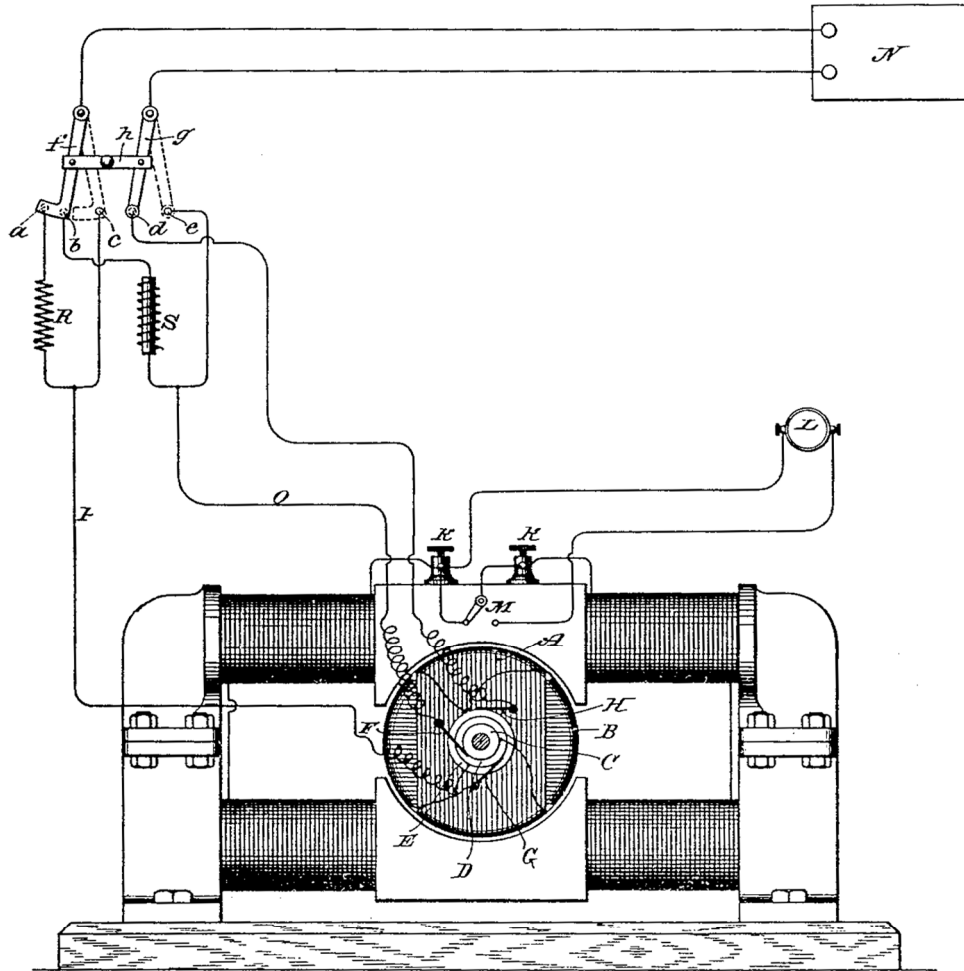
见证人: R. J. 斯托尼、E. P. 考芬。

(No Model.)

N. TESLA.
ELECTRO MAGNETIC MOTOR.

No. 418,248.

Patented Dec. 31, 1889.



Witnesses:
Hapthael Netter
Robt. F. Gaylord

Inventor
Nikola Tesla
By
Duncan, Curtis & Page
Attorneys.

ELECTRO-MAGNETIC MOTOR.

电磁电动机

NIKOLA TESLA, OF NEW YORK, N. Y., ASSIGNOR TO THE TESLA ELECTRIC
COMPANY, OF SAME PLACE.

纽约州纽约市的尼古拉·特斯拉将专利转让给纽约市的特斯拉电气公司

SPECIFICATION forming part of Letters Patent No. 424,036, dated March 25, 1890.

Application filed May 20, 1889. Serial No. 311,416. (No model.)

该说明书形成了颁发于 1890 年 3 月 25 日编号为 424,036 的专利证书的一部分。

申请于 1889 年 3 月 20 日提交。序列号为 311,416。(没有模型)

To all whom it may concern:

致所有相关人士:

Be it known that I, NIKOLA TESLA, a subject of the Emperor of Austria-Hungary, from Smiljan, Lika, border country of Austria-Hungary, residing at New York, in the county and State of New York, have invented certain new and useful Improvements in Electro-Magnetic Motors, of which the following is a specification, reference being had to the drawings accompanying and forming a part of the same.

众所周知，我、尼古拉·特斯拉、一位奥匈帝国的臣民，来自奥匈帝国边境地区的利卡县的史密里安村，现在居住在纽约州纽约郡纽约市，在电磁电动机方面已经发明了某些新的和有用的改进，以下是该发明一个说明书，必须参考随附的图纸，它已经形成了该说明的一部分。

I have invented and elsewhere described an electro-magnetic motor operated or adapted to be operated by an alternating electric current, and which is now commonly designated, whether correctly or not, a “magnetic-lag” motor. The main distinguishing features of this motor are the following: An armature is mounted within the magnetizing influence of a certain number of field magnets or poles of different magnetic susceptibility—that is to say, poles of unequal length, mass, or composition—and wound with coils adapted in the operation of the motor to be connected to a source of alternating currents. When an alternating current is passed through the coils of such a motor, the field magnets or poles do not appear to manifest their attractive effect upon the armature simultaneously, the magnetic attraction of some appearing to lag behind that of others, with the result of producing a torque and rotation of the motor. Generally I have made such motors with closed armature-coils.

我已经发明并在别处描述了一种由交流电流运行或适于由交流电流运行的电磁电动机，不管正确与否，该电动机现在通常被称为“磁滞后”电动机。这种电动机的主要区别特征如下：一个电枢被安装在一定数量的不同磁化率（也就是说，不同长度、质量或成分的磁极）的场磁体或磁极的磁影响范围内，并且缠绕有适合于电动机运行的线圈，并连接到一个交流电源。当一个交流电通过这种电动机的线圈时，场磁体或磁极似乎不会同时表现出对电枢的吸引力，一些场磁体或磁极的磁性吸引力似乎滞后于另一些场磁体或磁极的磁性吸引力，从而产

生电动机的转矩和旋转。总的来说，我已经做出了这种具有闭合电枢线圈的电动机。

I have invented another form of motor, which, for similar reasons, may be called a "magnetic-lag" motor; but in operation it differs from that which I have above described in that the attractive effects or phases of the poles, while lagging behind the phases of current which produce them, are manifested simultaneously and not successively.

我发明了另一种形式的电动机，出于类似的原因，可以被称为“磁滞后”电动机；但在运行中，它与我上面描述的不同之处在于，磁极的吸引效应或相位，虽然落后于产生它们的电流相位，但却是同时而不是相继表现出来的。

To carry out this invention I employ a motor embodying the principle of construction of a motor described and claimed in an application filed by me January 8, 1889, No. 295,745, to the extent that both the armature and field receive their magnetism from a single energizing-coil or a plurality of coils acting as one.

为了实施本发明，我采用了一种电动机，该电动机体现了我在 1889 年 1 月 8 日提交的第 295,745 号申请中描述和要求保护的一个电动机的构造原理，在某种程度上而言，电枢和磁场都从单个励磁线圈或作为一个整体的多个线圈接收它们的磁性。

A motor which embodies my invention, with certain modifications thereof, is illustrated in the accompanying drawings.

在附图中展示了体现本发明的电动机，并对其进行了某些修改。

Figure 1 is a side view of the motor in elevation. Fig. 2 is a part-sectional view at right angles to Fig. 1. Fig. 3 is an end view in elevation and part section of a modification, and Fig. 4 is a similar view of another modification.

图 1 是电动机的正视图。图 2 是与图 1 成直角的局部截面图。图 3 是一种改型的端视图和局部截面图，图 4 是另一种改型的类似视图。

In Figs. 1 and 2, A designates a base or stand, and B B the supporting-frame of the motor. Bolted to the said supporting-frame are two magnetic cores or pole-pieces C C', of iron or soft steel. These may be subdivided or laminated, in which case hard iron or steel plates or bars should be used, or they should be wound with closed coils. D is a circular disk-armature built up of sections or plates of iron and mounted in the frame between the pole-pieces C C', which latter are preferably curved to conform to the circular shape thereof. I may wind this disk with a number of closed coils E. F F are the main energizing-coils, supported in any convenient manner by the supporting-frame, or otherwise, but so as to include within their magnetizing influence both the pole-pieces C C' and the armature D. The pole-pieces C C' project out beyond the coils F F on opposite sides, as indicated in the drawings. If an alternating current be passed through the coils F F, rotation of the armature will be produced, and this rotation I explain by the following apparent action or mode of operation: An impulse of current in the coils F F establishes two polarities in the motor. The protruding end of pole-piece C, for instance, will be of one sign, and the corresponding end of pole-piece C' will be of the opposite sign. The armature

also exhibits two poles at right angles to the coils F F, like poles to those in the pole-pieces being on the same side of the coils. While the current is flowing there is no appreciable tendency to rotation developed; but after each current impulse ceases or begins to fall the magnetism in the armature and in the ends of the pole-pieces C C' lags or continues to manifest itself, which produces a rotation of the armature by the repellent force between the more closely approximating points of maximum magnetic effect. This effect is continued by the reversal of current, the polarities of field and armature being simply reversed. One or both of the elements—the armature or field—may be wound with closed induced coils to intensify this effect, although in the drawings I have shown but one of the fields, each element of the motor really constitutes a field, wound with the closed coils, the currents being induced mainly in those convolutions or coils which are parallel to the coils F F. A modified form of this motor is shown in Fig. 3. In this form G is one of two standards that support the bearings for the armature-shaft. H H are uprights or sides of a frame, preferably magnetic, the ends C C' of which are bent, substantially as shown, to conform to the shape of the armature D and form field-magnet poles. The construction of the armature may be the same as in the previous figure, or it may be simply a magnetic disk or cylinder, as shown, and a coil or coils F F are secured in position to surround both the armature and the poles C C'. The armature is detachable from its shaft, the latter being passed through the armature after it has been inserted in position. The operation of this form of motor is the same in principle as that previously described and needs no further explanation.

在图 1 和 2 中，A 表示底座或支架，B B 表示电动机的支撑框架。用螺栓固定在所述支撑框架上的是两个铁制或软钢制的磁芯或磁极 C C'。这些铁芯或磁极可以是细分的或层叠的，在这种情况下，应该使用硬铁或钢的板或棒，或者应该用闭合线圈缠绕。D 是由铁片或铁板构成的一个圆盘形电枢，安装在极靴 C C' 之间的框架中，后者最好是弯曲的，以符合其圆形形状。我可以用许多闭合的线圈 E 来缠绕在这个圆盘上。F F 是主励磁线圈，以任何方便的方式由支撑框架或其他方式支撑，但在其磁化影响范围内包含极靴 C C' 和电枢 D。如图所示，极靴 C C' 在径向相对侧突出线圈 F F 之外。如果有一个交流电通过线圈 F F，就会产生电枢的旋转，这种旋转可以用下面明显的动作或工作方式来说明：线圈 F F 中的电流脉冲在电动机中建立了两极。例如，极靴 C 的突出端将是一个符号，而极靴 C' 的相应端将是相反的符号。电枢还具有两个与线圈 F F 成直角的磁极，就像在线圈同一侧的极靴中的磁极一样。当电流正在流动时，没有明显的旋转趋势；但是在每一个电流脉冲停止或开始下降后，电枢和极靴 C C' 的端部中的磁性会表现出滞后或继续显现，这个结果可以通过最大磁效应的更加靠近中的不同点的相互间的排斥力来产生电枢的一个旋转。这种效应随着电流的反转而继续，磁场和电枢的极性只是简单地反转。一个或两个组件——电枢或磁场——可以通过缠绕上闭合的感应线圈来加强这种效果，虽然在图中我只展示了磁场中的一个，但电动机的每个组件实际上都构成了一个磁场，这些组件上缠绕了闭合线圈，电流主要在平行于线圈 F F 的那些匝圈或线圈中感应产生。图 3 展示了这种电动机的一种改进形式。在这种形式中，G 是支持电枢轴轴承的两个框架之一。H H 是框架的立柱或侧边，最好是磁性的，其端部 C C' 弯曲，基本上如图所示，以符合电枢 D 的形状并形成场磁体磁极。电枢的结构可以与前面的图相同，或者它可以简单地是一个圆盘或圆柱，如图所示，并且一个或多个线圈 F F 被固定在围绕着电枢和磁极 C C' 的位置上。电枢可从其轴上拆卸，后者在被插入到位后穿过电枢。这种形式的电动机的运行原理与前面描述的相同，无需进一步解释。

One of the most important features in alternating-current motors is that they should be adapted to and capable of running efficiently in the alternating systems in present use, in which almost without exception the generators yield a very high number of alternations. Such a motor I have designed by a

development of the principle of the motor shown in Fig. 3, making a multipolar motor, which is illustrated in Fig. 4. In the construction of this motor I employ an annular magnetic frame J, with inwardly-extending ribs or projections K, the ends of which all bend or turn in one direction and are generally shaped to conform to the curved surface of the armature. Coils F F are wound from one part K to the one next adjacent, the ends or loops of each coil or group of wires being carried over toward the shaft, so as to form U-shaped groups of convolutions at each end of the armature. The pole-pieces C C', being substantially concentric with the armature, form ledges, along which the coils are laid and should project to some extent beyond the coils, as shown. The cylindrical or drum armature D is of the same construction as in the other motors described, and is mounted to rotate within the annular frame J and between the U-shaped ends or bends of the coils F. The coils F are connected in multiple or in series with a source of alternating currents, and are so wound that with a current or current impulse of given direction they will make the alternate pole-pieces C of one polarity and the other pole-pieces C' of the opposite polarity. The principle of the operation of this motor is the same as the other herein described, for, considering any two pole-pieces C C', a current impulse passing in the coil which bridges them or is wound over both tends to establish polarities in their ends of opposite sign and to set up in the armature-core between them a polarity of the same sign as that of the nearest pole-piece C. Upon the fall or cessation of the current impulse that established these polarities the magnetism which lags behind the current phase, and which continues to manifest itself in the polar projections C C' and the armature, produces by repulsion a rotation of the armature. The effect is continued by each reversal of the current. What occurs in the case of one pair of pole-pieces occurs simultaneously in all, so that the tendency to rotation of the armature is measured by the sum of all the forces exerted by the pole-pieces, as above described. In this motor also the magnetic lag or effect is intensified by winding one or both cores with closed induced coils. The armature-core is shown as thus wound. When closed coils are used, the cores should be laminated.

交流电动机中的一个最重要的特点是,它们应该适应并能够在目前使用的交流系统中有效地运行,在这种交流系统中,发电机几乎无一例外地产生大量的交替。我通过对图 3 中所示的电动机原理的发展设计了这样一种电动机,制成一个多极电动机,如图 4 所示。在这种电动机的结构中,我采用了一个环形的磁性框架 J,该框架具有向内延伸的肋拱或突起 K,其端部都在一个方向上弯曲,并且其形状通常与电枢的曲面相吻合。线圈 F F 从一个部件 K 缠绕到下一个相邻的部分,每个线圈或每个导线组的端部或环路都被转向,弯曲部分朝向轴,从而在电枢的每个端部形成 U 形匝圈组。如图所示,基本上与电枢同心的极靴 C C' 形成壁架,线圈沿着该壁架放置,并且壁架应该伸出线圈一定程度。圆柱形或鼓形电枢 D 的结构与所述的其它电动机相同,并且安装在环形框架 J 内,并在线圈 F 的 U 形端部或弯曲部之间旋转。线圈 F 与一个交流电源并联或串联,并且线圈 F 缠绕成可以利用给定方向的电流或电流脉冲,这使得线圈 F 形成一种极性的交替极靴 C 和另一种相反极性的交替极靴 C'。这种电动机的运行原理与这里描述的另一种电动机相同,因为,考虑到任何两个极靴 C C',在桥接它们的或缠绕在它们上的线圈中通过的电流脉冲倾向于在它们的端部建立符号相反的磁极,并倾向于在它们之间的电枢铁芯中建立与最近的极靴 C 相同符号的一个磁极。在建立这些磁极的电流脉冲下降或停止时,滞后于电流相位并继续在磁极突起 C C' 和电枢中表现出来的磁性通过排斥产生电枢的旋转。这种效应随着电流的每次反转而持续。在一对极靴中发生的事情在所有的极靴对中同时发生,因此电枢的旋转趋势由极靴施加的所有力的总和来测量,如上所述。在这种电动机中,在一个或两个铁芯上缠绕闭合感应线圈,也可以增强磁滞后或磁效应。电枢铁芯显示为如此缠绕。当使用闭合线圈时,铁芯应该层叠的。

It is evident that a pulsatory as well as an alternating current might be used to drive or operate the motors herein described; but I prefer to use alternating currents.

很明显，脉动电流以及交流电流可以用来驱动或操作这里描述的电动机；但是我更喜欢用交流电。

It will be understood that the degree of subdivision, the mass of the iron in the cores, their size, and the number of alternations in the current employed to run the motor must be taken into consideration in order to properly construct this motor. In other words, in all such motors the proper relations between the number of alternations and the mass, size, or quality of the iron must be preserved in order to secure the best results. These are matters, however, that are well understood by those skilled in the art.

应当理解，为了适当地构造该电动机，必须考虑细分的程度、铁芯中的铁的重量、铁芯的尺寸以及用于运行电动机的电流的交替次数。换句话说，在所有这样的电动机中，交替次数与铁的重量、尺寸或品质之间适当关系必须保持，以确保最好的结果。然而，这些是本领域技术人员所熟知的事情

What I claim is—

我主张的是—

1. In an alternating-current motor, the combination, with the armature and field-cores, of stationary energizing-coils enveloping the said cores and adapted to produce polarities or poles in both, the field-cores extending out from the coils and constructed so as to exhibit the magnetic effect imparted to them after the fall or cessation of current impulse producing such effect, as set forth.

1、在一个交流电动机中，静态励磁线圈与电枢和励磁铁芯的组合，该静态励磁线圈包围所述铁芯并适于在两者中产生极性或磁极，该励磁铁芯从线圈中伸出并构造成能在产生施加给它们的磁效应的电流脉冲下降或停止后表现出这种磁效应，如上所述。

2. In an alternating-current motor, the combination, with an armature-core circular in configuration, of a supporting-frame, field-cores extending therefrom over portions of the periphery of the armature, and energizing-coils surrounding said armature and parts of the field-cores, as set forth.

2、在一个交流电动机中，存在一个组合，它包括：一个圆形结构的电枢铁芯、一个支撑框架、励磁铁芯以及励磁线圈，该励磁铁芯延伸到电枢的外周部分之上，该励磁线圈围绕着所述电枢和励磁铁芯的部件，如上所述。

3. The combination, with the rotatably-mounted armature, of the circular frame J, the ribs K, with polar extensions extending over portions of the armature, and the energizing-coils F, wound over portions of the pole-pieces and carried in loops over the ends of the armature, as herein set forth.

3、存在一个组合，它包括：圆形框架J、在电枢部分上方具有极性延伸部的肋拱K、被缠绕在极靴部分上的励磁线圈F，这些线圈以环路的形式被承载在电枢的端部上方，如本文所述。

NIKOLA TESLA.

尼古拉·特斯拉

Witnesses:

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见证人：

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N. TESLA.
ELECTRO MAGNETIC MOTOR.

No. 424,036.

Patented Mar. 25, 1890.

Fig. 1

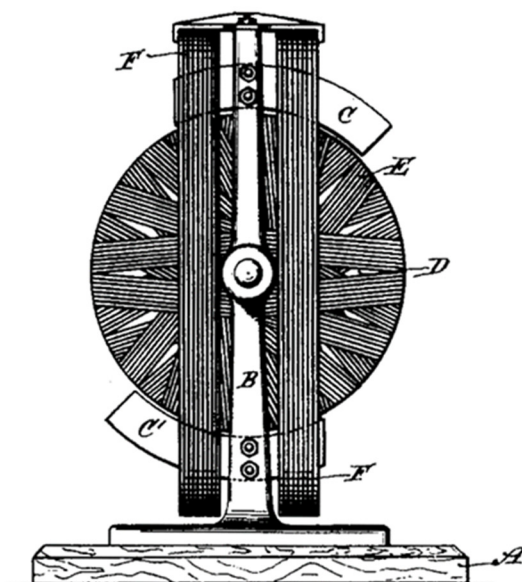
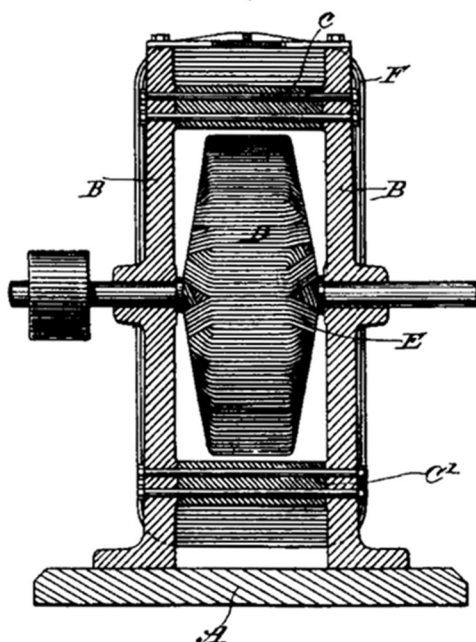


Fig. 2



Witnesses:
Haptail Vetter
Frank & Hartley

Inventor
Nikola Tesla
By
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ELECTRO MAGNETIC MOTOR.

No. 424,036.

Patented Mar. 25, 1890.

Fig. 3

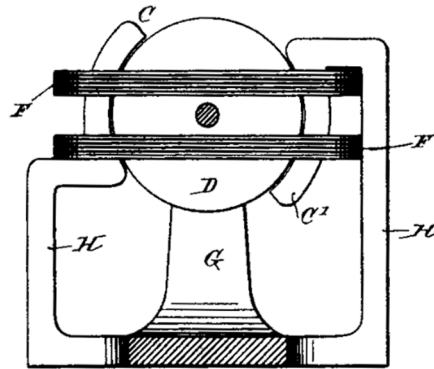
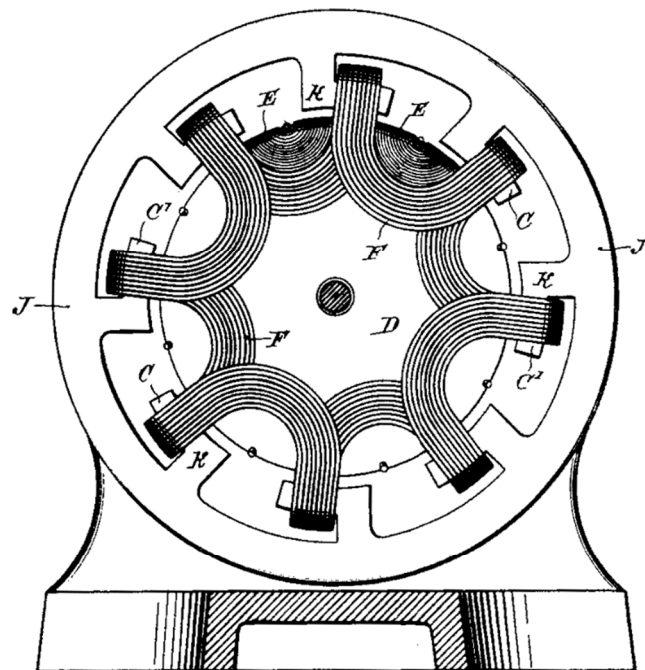


Fig. 4



Witnesses:
Raphael Netter
Frank Hartley

Inventor
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ALTERNATING-CURRENT ELECTRO- MAGNETIC MOTOR.

交流电磁电动机

NIKOLA TESLA, OF NEW YORK, N. Y., ASSIGNOR TO THE TESLA ELECTRIC
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纽约州纽约市的尼古拉·特斯拉将专利权转让给纽约市的特斯拉电气公司

SPECIFICATION forming part of Letters Patent No. 433,700, dated August 5, 1890.

Application filed May 26, 1890. Serial No. 345,388. (No model.)

该说明书形成了颁发于 1890 年 8 月 5 日编号为 433,700 的专利证书的一部分。

申请于 1890 年 5 月 26 日提交。序列号为 345,388。(没有模型)

To all whom it may concern:

致所有相关人士:

Be it known that I, NIKOLA TESLA, a subject of the Emperor of Austria-Hungary, from Smiljan, Lika, border country of Austria-Hungary, residing at New York, in the county and State of New York, have invented certain new and useful Improvements in Alternating-Current Electro-Magnetic Motors, of which the following is a specification, reference being had to the drawings accompanying and forming a part of the same.

众所周知，我、尼古拉·特斯拉、一位奥匈帝国的臣民，来自奥匈帝国边境地区的利卡县的史密里安村，现在居住在纽约州纽约郡纽约市，在交流电磁电动机方面已经发明了某种新的和有用的改进，以下是该发明一个说明书，必须参考随附的图纸，它已形成该说明书的一部分。

This invention is an improvement in that class of electro-magnetic motors in which the rotation is produced by the progressive movement or effect of the maximum magnetic points or poles produced by the conjoint action or effect of two energizing-circuits through which are passed alternating currents, or currents of rapidly-varying strength of a kindred nature.

本发明是对这类电磁电动机的一个改进，在这类电动机中，旋转是由最大的磁力点或磁极的渐进运动或渐进效应产生的，最大的磁力点或磁极是由两个通电电路的联合作用或联合效应产生的，交流电或类似性质的强度快速变化的电流通过这两个励磁电路。

The improvements subject of this application are more particularly applicable to that class of motors in which two or more sets of energizing-magnets are employed, and in which by artificial means a certain interval of time is made to elapse between the respective maximum or minimum periods or phases of their magnetic attraction or effect. This interval or difference in phase between the two sets of magnets,

when artificially produced, is limited in extent. It is desirable, however, for the economical working of such motors that the strength or attraction of one set of magnets should be maximum at the time when that of the other set is minimum and conversely; but these conditions have not heretofore been realized except in cases where the two currents have been obtained from independent sources in the same or different machines.

本申请的改进主题更特别地适用于这样一类电动机,在该类电动机中采用了两组或多组励磁磁体,并且其中通过人工手段使得在它们的磁吸引或磁效应的各自的最大值周期或最小值周期或相位之间经过一定的时间间隔。当这两组磁体之间的这种时间间隔或相位差由人工产生时,这种时间间隔或相位差在程度上是有限的。然而,为了这种电动机的经济运行,希望一组磁体的强度或吸引力在另一组磁体的强度或吸引力最小时应是最大的,反之亦然;但是这些条件迄今为止还没有实现,除非这两个电流是从相同或不同机器中的独立电源获得的。

The object of the present invention is to establish conditions more nearly approaching the theoretical requirements of perfect working, or, in other words, to produce artificially a difference of magnetic phase by means of a current from a single primary source sufficient in extent to meet the requirements of practical and economical working.

本发明的目的是建立更接近完美工作的理论要求的条件,或者,换句话说,通过来自单个初级源的电流来人工产生磁相位差,其程度足以满足实际工作和经济工作的要求。

In carrying out my invention I employ a motor with two sets of energizing or field magnets, each wound with coils connected with a source of alternating or rapidly-varying currents, but forming two separate paths or circuits. The magnets of one set I protect to a certain extent from the energizing action of the current by means of a magnetic shield or screen interposed between the magnet and its energizing-coil. This shield is properly adapted to the conditions of particular cases, so as to shield or protect the main core from magnetization until it has become itself saturated and no longer capable of containing all the lines of force produced by the current. By this means it will be seen that the energizing action begins in the protected set of magnets a certain arbitrarily-determined period of time later than in the other, and that by this means alone or in conjunction with other means or devices heretofore employed a practically-economical difference of magnetic phase may readily be secured.

在实施我的发明时,我使用了具有两组场磁体的电动机,每组都缠绕有与一个交流电源或快速变化的电流源连接的线圈,但形成了两个独立的路径或电路。我通过在磁体和它的励磁线圈之间插入磁屏蔽,在一定程度上保护一组磁体免受电流的励磁作用。该屏蔽适当地适用于特定情况的条件,以便屏蔽或保护主铁芯免于磁化,直到它本身变得饱和并且不再能够容纳由电流产生的所有磁力线。通过这种方式,可以看出,在受保护的磁体组中的励磁作用要比在另一组中的励磁作用晚了某个任意确定的时间段才开始,并且通过单独使用这种方式或者与迄今为止所采用的其他工具或与设备结合使用,可以容易地确保一个实际上经济的磁相位差。

The nature and operation of the invention will be more fully explained by reference to the accompanying drawings.

本发明的本质和运行将通过参考附图得到更充分的解释。

Figure 1 is a view of a motor, partly in section, with a diagram illustrating the invention. Fig. 2 is a similar view of a modification of the same.

图 1 是电动机的部分截面图，用一个示意图展示了本发明。图 2 是其修改的类似视图。

In Fig. 1, which exhibits the simplest form of the invention, A A is the field-magnet of a motor, having, say, eight poles or inwardly-projecting cores B and C. The cores B form one set of magnets and are energized by coils D. The cores C, forming the other set, are energized by coils E, and the coils are connected, preferably, in series with one another, in two derived or branched circuits F G, respectively, from a suitable source of current. Each coil E is surrounded by a magnetic shield H, which is preferably composed of an annealed, insulated, or oxidized iron wire wrapped or wound on the coils in the manner indicated, so as to form a closed magnetic circuit around the coils and between the same and the magnetic cores C. Between the pole pieces or cores B C is mounted the armature K, which, as is usual in this type of machines, is wound with coils L closed upon themselves. The operation resulting from this disposition is as follows: If a current impulse be directed through the two circuits of the motor, it will quickly energize the cores B, but not so the cores C, for the reason that in passing through the coils E there is encountered the influence of the closed magnetic circuits formed by the shields H. The first effect is to effectively retard the current impulse in circuit G, while at the same time the proportion of current which does pass does not magnetize the cores C, which are shielded or screened by the shields H. As the increasing electro-motive force then urges more current through the coils E, the iron wire H becomes magnetically saturated and incapable of carrying all the lines of force, and hence ceases to protect the cores C, which become magnetized, developing their maximum effect after an interval of time subsequent to the similar manifestation of strength in the other set of magnets, the extent of which is arbitrarily determined by the thickness of the shield H, and other well-understood conditions.

在图 1 中，展示了本发明的最简单形式，A A 是一个电动机的场磁体，具有例如八个磁极或向内突出的铁芯 B 和 C。铁芯 B 形成一组磁体，并由线圈 D 励磁。形成另一组的铁芯 C 由线圈 E 励磁，并且线圈最好彼此串联连接，分别位于来自合适的电流源的两个间接电路（通过线圈进行连接的电路）F G 中。每个线圈 E 被一个磁屏蔽体 H 包围，该磁屏蔽体最好由一个退火的、被绝缘的或氧化的铁丝，并以所示方式缠绕在线圈上构成，从而在线圈周围以及在线圈和磁芯 C 之间形成一个闭合磁路。在极靴或铁芯 B C 之间安装有电枢 K，在这种类型的机器中，电枢 K 通常缠绕有闭合的线圈 L。这种配置产生的运行如下：如果一个电流脉冲被引导通过电动机的两个电路，它将快速励磁铁芯 B，但不励磁铁芯 C，因为在通过电流线圈 E 时，遇到由磁屏蔽体 H 形成的闭合磁路的影响。第一个效果是有效地延迟了电路 G 中的电流脉冲，同时通过电流的部分不会磁化被屏蔽体 H 屏蔽的铁芯 C。当增加的电动势促使更多的电流通过线圈 E 时，铁丝 H 变得磁饱和，不能承载所有的磁力线，因此不再保护铁芯 C，铁芯 C 开始被磁化，在另一组磁体中出现类似的强度之后的一段时间间隔后，铁芯 C 发挥出它们最大的作用，其程度由屏蔽体 H 的厚度和其他众所周知的条件任意确定。

From the above it will be seen that the apparatus or device acts in two ways. First, by retarding the current, and, second, by retarding the magnetization of one set of the cores, from which its effectiveness will readily appear.

从上面可以看出，该装置或设备以两种方式起作用。第一，通过延迟电流，第二，通过延迟一组铁芯的磁化，其有效性将很容易显现。

Many modifications of the principle of this invention are possible. One useful and efficient application of the invention is shown in Fig. 2. In said figure a motor is shown similar in all respects to that above described, except that the iron wire H, which is wrapped around the coils E, is in this case connected in series with the coils D. The iron-wire coils H, are connected and wound, so as to have little or no self-induction, and being added to the resistance of the circuit F the action of the current in that circuit will be accelerated, while in the other circuit G it will be retarded. The shield H may be made in many forms, as will be understood, and used in different ways, as appears from the foregoing description. I do not, however, limit myself to any specific form or arrangement; but

本发明的原理的许多修改是可能的。图 2 展示了本发明的一个有用且有效的应用。在所述附图中，除了缠绕在线圈 E 周围的铁丝 H 在这种情况下与线圈 D 串联连接之外，电动机在所有方面都与上述类似。铁丝线圈 H 被连接和缠绕，以便具有很少的自感或没有自感，并且被添加到电路 F 的电阻中，该电路中的电流的作用将被加速，而在另一个电路 G 中，电流的作用将被延迟。可以理解的是，屏蔽体 H 可以制成多种形式，并以不同的方式使用，如从前面的描述中可以看出的。然而，我不把自己局限于任何特定的形式或安排；但是

What I claim is—

我主张的是—

1. In an alternating-current motor having two energizing-circuits, the combination, with the magnetic cores and coils of one of the circuits, of interposed magnetic shields or screens for retarding the magnetization of said cores, as set forth.

1、在具有两个励磁电路的一个交流电动机中，被插入的磁屏蔽体与磁芯以及这两个电路中的其中一个电路的线圈的组合，该屏蔽体用于延迟所述磁芯的磁化，如上所述。

2. In an alternating-current motor having two energizing-circuits, the combination, with the magnetic cores and the coils of one of the circuits wound thereon, of magnetic shields or coils wound around said coils at right angles to their convolutions, as set forth.

2、在具有两个励磁电路的一个交流电动机中，磁屏蔽体、磁芯和缠绕在该磁芯上的这两个电路中的其中一个电路的线圈的组合，该磁屏蔽体以与所述线圈的匝圈成直角的方式缠绕在所述线圈上，如上所述。

3. In an alternating-current motor having two energizing-circuits, the combination, with the magnetic cores and the coils of one of the circuits which energize the said cores, of magnetic shields forming closed magnetic circuits around the coils and interposed between the coils and cores, as set forth.

3、在具有两个励磁电路的一个交流电动机中，磁芯和励磁所述磁芯的这两个电路中的其中一个电路中的线圈，以及在所述线圈周围形成闭合磁路的磁屏蔽，磁屏蔽插入线圈和磁芯之间，如上所述。

4. In an alternating-current motor having two energizing-circuits derived from the same source, the combination, with the cores and the coils of one of the circuits that energizes the same, of insulated

iron-wire coils wound on the said energizing-coils at right angles to their convolutions and connected up in series with the coils of the other energizing-circuit, as set forth.

4、在具有源自同一电源的两个励磁电路的交流电动机中，绝缘铁丝线圈与铁芯以及这两个电路中的其中一个电路的线圈的组合，绝缘铁丝线圈以与所述励磁线圈的匝圈成直角的方式缠绕在所述励磁线圈上，并与另一个励磁电路的线圈串联连接，如上所述。

NIKOLA TESLA.
尼古拉·特斯拉

Witnesses:

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(No Model.)

N. TESLA.

ALTERNATING CURRENT ELECTRO MAGNETIC MOTOR.

No. 433,700.

Patented Aug. 5, 1890.

Fig. 1

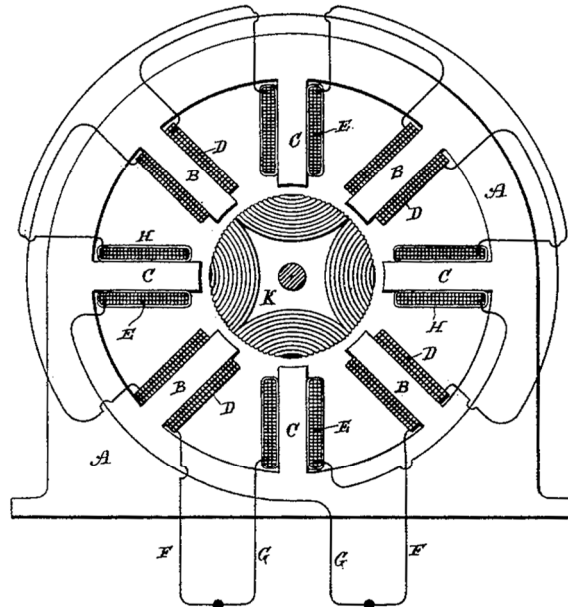
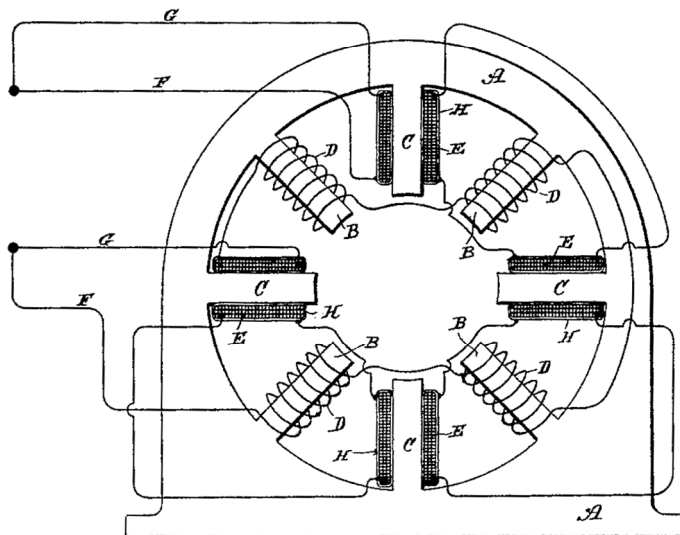


Fig. 2



Witnesses:
Raphael Netter
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Inventor
Nikola Tesla
by
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ALTERNATING-CURRENT MOTOR.

交流电动机

NIKOLA TESLA, OF NEW YORK, N. Y., ASSIGNOR TO THE TESLA ELECTRIC
COMPANY, OF SAME PLACE.

纽约州纽约市的尼古拉·特斯拉将专利权转让给纽约市的特斯拉电气公司。

SPECIFICATION forming part of Letters Patent No. 433,701, dated August 5, 1890.

Application filed May 26, 1890. Serial No. 345,389. (No model.)

该说明书形成了颁发于 1890 年 8 月 5 日编号为 433,701 的专利证书的一部分。

申请于 1890 年 5 月 26 日提交。序列号为 345,389。(没有模型)

To all whom it may concern:

致所有相关人士:

Be it known that I, NIKOLA TESLA, a subject of the Emperor of Austria-Hungary, from Smiljan, Lika, border country of Austria-Hungary, residing at New York, in the county and State of New York, have invented certain new and useful Improvements in Alternating-Current Motors, of which the following is a specification, reference being had to the drawings accompanying and forming a part of the same.

众所周知，我、尼古拉·特斯拉、一位奥匈帝国的臣民，来自奥匈帝国边境地区的利卡县的史密里安村，现在居住在纽约州纽约郡纽约市，在交流电动机方面已经发明了某种新的和有用的改进，以下是该发明一个说明书，必须参考随附的图纸，它已形成该说明书的一部分。

This invention relates to that class of alternating-current motors in which the field-magnets are energized by coils connected up in two circuits derived from the same source and having different degrees of self-induction, whereby the currents in one circuit or branch are retarded more than in the other, with the result of producing a progressive advance or rotation of the points of maximum magnetic effect in the field that maintains the armature in rotation. In motors of this kind I have employed, among other means, a self-induction coil in one circuit and a dead resistance in the other, or I have secured the same result by the special character of the winding of the two circuits, and in still another instance I have so constructed the motor that the retarded-current coils were nearly enclosed by iron, whereby the self-induction of such coils was very greatly increased.

本发明涉及一类交流电动机，其中场磁体由连接在两个电路中的线圈所励磁，这两个电路源自同一个电源并具有不同程度的自感，由此一个电路或分支中的电流比另一个电路或分支中的电流延迟更多，结果在维持电枢旋转的磁场中产生最大磁效应点的渐进转移或旋转。在这种类型的电动机中，我采用了其他手段，一个电路中的自感线圈和一个吸收电阻，或者我通过两个电路的绕组的特殊特性确保了相同的结果，在另一个实例中，我这样构建电动机，被延迟的电流所通过的线圈几乎被铁包围，从而这种线圈的自感大大增加。

The invention subject of this application is an improvement on this last-named plan.

本申请的发明主题是对这个最后提到的方案的改进。

In carrying out the invention I construct a field-magnet having two sets of poles or inwardly-projecting cores and placed side by side, so as practically to form two fields of force and alternately disposed—that is to say, with the poles of one set or field opposite the spaces between the other. I then connect the free ends of one set of poles by means of laminated-iron bands or bridge-pieces of considerably smaller cross-section than the cores themselves, whereby the cores will all form parts of complete magnetic circuits. When the coils on each set of magnets are connected in multiple circuits or branches from a source of alternating currents, electro-motive forces are set up in or impressed upon each circuit simultaneously; but the coils on the magnetically bridged or shunted cores will have, by reason of the closed magnetic circuits, a high self-induction, which retards the current, permitting at the beginning of each impulse but little current to pass. On the other hand, no such opposition being encountered in the other set of coils, the current passes freely through them, magnetizing the poles on which they are wound. As soon, however, as the laminated bridges become saturated and incapable of carrying all the lines of force, which the rising electro-motive force, and consequently increased current, produce, free poles are developed at the ends of the cores, which, acting in conjunction with the others, produce rotation of the armature.

在实施本发明时，我构建了一种场磁体，该场磁体具有两组磁极或向内突出的铁芯，并且并排放置，以便实际上形成两个力场并交替布置——也就是说，一组磁极在另一组磁极间的空间的对面。然后我利用叠片铁带或横截面比铁芯本身小得多的桥接件连接一组磁极的游离端，因此所有的铁芯将形成完整磁路的各个部分。当每组磁体上的线圈并联到来自一个交流电源的多个电路或支路时，在每个电路中同时建立或施加电动势；但是，由于闭合磁路的原因，位于被磁桥接或被磁分流的铁芯上的线圈将具有一个高自感，这延迟了电流，允许在每个脉冲开始时仅有少量电流通过。另一方面，在另一组线圈中没有遇到这样的对抗，电流自由地通过它们，磁化它们所缠绕的磁极。然而，一旦叠片桥变得饱和，无法承载上升的电动势和随之增加的电流产生的所有磁力线，在铁芯的端部就会产生自由磁极，这些磁极与其他磁极共同作用，产生电枢的旋转。

The construction in detail by which this invention is illustrated is shown in the accompanying drawings.

附图中展示了本发明的详细结构。

Figure 1 is a view in side elevation of a motor embodying the invention. Fig. 2 is a vertical cross-section of the same.

图 1 是体现本发明的电动机的侧视图。图 2 是它的垂直截面图。

A is the frame of the motor, which is preferably built up of sheets of iron punched out to the desired shape and bolted together with insulation of a proper character between the sheets. When complete, the frame makes a field-magnet with inwardly-projecting pole-pieces B and C. To adapt them to the requirements of this particular case these pole-pieces are out of line with one another, those marked B surrounding one end of the armature and the others, as C, the opposite end, and they are disposed

alternately—that is to say, the pole-pieces of one set occur in line with the spaces between those of the other sets.

A 是电动机的框架，它最好由冲压成所需形状的铁片组成，并用适当特性的绝缘材料栓接在一起。完成后，框架形成一个带有向内突出的磁极靴 B 和 C 的场磁体。为了适应这种特殊情况的要求，这些极靴彼此不在一条直线上，那些标记为 B 的围绕电枢的一端，其他的标记为 C，围绕电枢的另一端，它们被交替放置——也就是说，一组极靴与另一组极靴间的空间成直线排列。

The armature D is of cylindrical form, and is also laminated in the usual way and is wound longitudinally with coils closed upon themselves. The pole-pieces C are connected or shunted by bridge-pieces E. These may be made independently and attached to the pole-pieces, or they may be parts of the forms or blanks stamped or punched out of sheet-iron. Their size or mass is determined by various conditions, such as the strength of the current to be employed, the mass or size of the cores to which they are applied, and other well-understood conditions.

电枢 D 是圆柱形的，并且也以通常的方式层叠，并且被线圈纵向缠绕，线圈自身闭合。极靴 C 由桥接件 E 连接或分流。这些可以独立制造并附在极靴上，或者它们可以从薄钢板上冲压出的模板或坯料的一部分。它们的尺寸或质量由各种条件决定，例如所用电流的强度、它们所应用的铁芯的质量或尺寸以及其他众所周知的条件。

Coils F surround the pole-pieces B, and other coils G are wound on the pole-pieces C. These coils are connected in series in two circuits, which are branches of a circuit from a generator of alternating currents, and they may be so wound, or the respective circuits in which they are included may be so arranged, that the circuit of coils G will have independently of the particular construction herein described a higher self-induction than the other circuit or branch.

线圈 F 围绕着极靴 B，其它线圈 G 缠绕在极靴 C 上。这些线圈在两个电路中串联连接，这两个电路是来自一个交流发电机的电路的分支，并且它们可以这样缠绕，或者包含它们的各个电路可以这样布置，使得线圈 G 的电路将独立于这里描述的特定结构而具有比其他电路或分支更高的自感。

The function of the shunts or bridges E is that they shall form with the cores C a closed magnetic circuit for a current up to a predetermined strength, so that when saturated by such current and unable to carry more lines of force than such a current produces they will to no further appreciable extent interfere with the development by a stronger current of free magnetic poles at the ends of the cores C.

分流器或桥接件 E 的功能是它们将与铁芯 C 形成一个闭合磁路，用于获得达到预定强度的一个电流，所以当被这种电流产生的磁力线填充饱和并且不能承载比这种电流产生的更多的磁力线时，它们就不会在更大程度上阻碍在铁芯末端的自由磁极的更强磁流的发展。

In such a motor the current is so retarded in the coils G and the manifestation of the free magnetism in the poles C is delayed beyond the period of maximum magnetic effect in poles B that a strong torque is produced and the motor operates with approximately the power developed in a motor of this kind energized by independently-generated currents differing by a full-quarter phase.

在这样的一个电动机中，电流在线圈 G 中被延迟，极 C 中的自由磁性的表现被延迟超过了极 B 中的最大磁效应的持续时间，从而产生一个强转矩，并且电动机以近似在这样的一个电动机中产生的功率运行，该电动机由相差完整的四分之一相位的独立产生的不同电流所激励。

What I claim in this application is—

我在这份申请中主张的是—

1. In an alternating-current motor having two sets or series of pole-pieces, the combination, with one of such sets or series, of magnetic shunts or bridges connecting their free ends, as herein set forth.

1、在一个具有两组或两个系列极靴的交流电动机中，存在着一个组合，包括：这样的两组极靴中的其中一组与磁分路或磁桥接件的组合，磁分路或磁桥接件连接这组极靴的自由端，如本文所述。

2. In an alternating-current motor having two sets or series of pole-pieces energized by coils in independent circuits from the same source, the combination, with one of the sets or series of pole-pieces, of magnetic shunts or bridges connecting their free ends, as described.

2、在一个具有两组或两个系列极靴的交流电动机中（这些极靴由源自同一电源的独立电路中的线圈所励磁），存在一个组合，它包括上述的两组极靴中的其中一组和磁分路或磁桥接件，磁分路或磁桥接件连接它们的自由端，如本文所述。

3. In an alternating-current motor having a laminated or subdivided field-magnet provided with two sets or series of cores or pole-pieces, the combination, with such pole-pieces, of energizing-coils connected, respectively, in two circuits derived from the same source of alternating currents and laminated or subdivided iron shunts or bridges of smaller cross-section than the pole-pieces and joining the free ends of all the cores or pole-pieces of one set to form closed magnetic circuits, as set forth.

3、在具有一个层叠或细分的场磁体的一个交流电动机中（该场磁体配有两组或两个系列的铁芯或极靴），存在一个组合，它包括被连接的励磁线圈和这种极靴，该励磁线圈分别连接到两个电路，这两个电路源自同一个的交流电源，并且层叠或细分的铁分路或桥接件的横截面小于极靴，并且连接所有铁芯或极靴的自由端以形成闭合磁路，如上所述。

4. In an alternating-current motor, the combination, with a set or series of field-poles and energizing-coils wound thereon, of an intermediate set of pole-pieces forming portions of closed magnetic circuits and coils thereon in a circuit derived from the same source of alternating currents as the other, as set forth.

4、在一个交流电动机中，存在一个组合，它包括一组或一个系列的场磁极和缠绕其上的励磁线圈；形成闭合磁路不同部分的一个中间极靴组；以及缠绕其上的被包含在一个电路中的线圈，这个电路与另一个电路源自同一个交流电源，如前所述。

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Witnesses:

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见证人:

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(No Model.)

N. TESLA.
ALTERNATING CURRENT MOTOR.

No. 433,701.

Patented Aug. 5, 1890.

Fig. 1

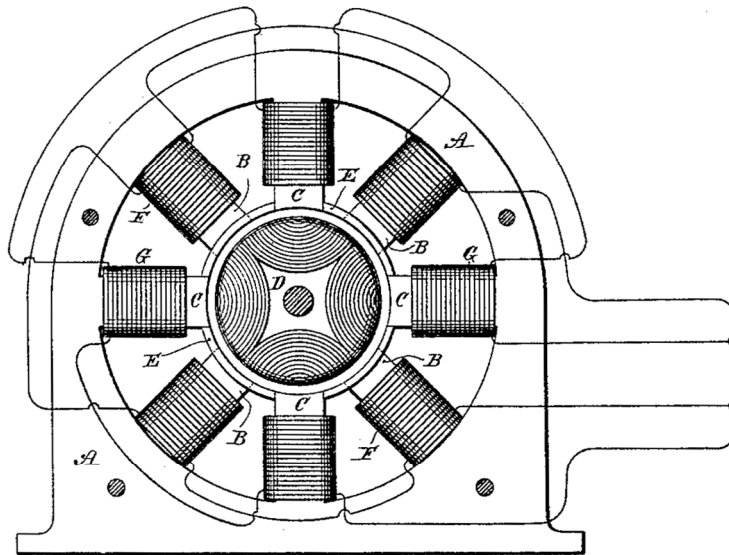
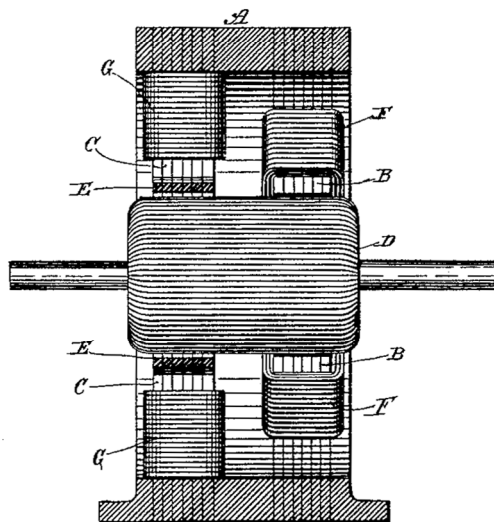


Fig. 2



Witnesses:

Raphael Netter
Ernest Hopkinson

Inventor

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by
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ELECTRICAL TRANSFORMER OR INDUCTION DEVICE.

电力变压器或感应装置

NIKOLA TESLA, OF NEW YORK, N. Y., ASSIGNOR TO THE TESLA ELECTRIC
COMPANY, OF SAME PLACE.

纽约州纽约市的尼古拉·特斯拉将专利权转让给纽约市的特斯拉电气公司。

SPECIFICATION forming part of Letters Patent No. 433,702, dated August 5, 1890.

Application filed May 26, 1890. Serial No. 345,390. (No model.)

该说明书形成了颁发于 1890 年 8 月 5 日编号为 433,702 的专利证书的一部分。

申请于 1890 年 5 月 26 日提交。序列号为 345,390。(没有模型)

To all whom it may concern:

致所有相关人士:

Be it known that I, NIKOLA TESLA, a subject of the Emperor of Austria-Hungary, from Smiljan, Lika, border country of Austria-Hungary, residing at New York, in the county and State of New York, have invented certain new and useful Improvements in Electrical Transformers or Induction Devices, of which the following is a specification, reference being had to the drawings accompanying and forming a part of the same.

众所周知,我、尼古拉·特斯拉、一位奥匈帝国的臣民,来自奥匈帝国边境地区的利卡县的史密里安村,现在居住在纽约州纽约郡纽约市,在电力变压器或感应装置方面已经发明了某种新的和有用的改进,以下是该发明一个说明书,必须参考随附的图纸,它已形成该说明书的一部分。

This invention is an improvement in electrical transformers or converters, and has for its main objects the provision of means for securing, first, a phase difference between the primary and secondary currents adapted to the operation of my alternating-current motors and other like purposes, and, second, a constant current for all loads imposed upon the secondary.

本发明是对电力变压器或电力转换器的一个改进,其主要目的是提供一种装置,首先,确保初级和次级电流之间的一个相位差,以适用于我的交流电动机和其它类似目的的操作,其次,得到一个恒向电流,用于强加在次级上的所有负载。

In transformers as constructed now and heretofore it will be found that the electro-motive force of the secondary very nearly coincides with that of the primary, being, however, of opposite sign. At the same time the currents, both primary and secondary, lag behind their respective electro-motive forces; but as this lag is practically or nearly the same in the case of each it follows that the maximum and minimum

of the primary and secondary currents will nearly coincide, but differ in sign or direction, provided the secondary be not loaded or if it contain devices having the property of self-induction. On the other hand, the lag of the primary behind the impressed electro-motive force may be diminished by loading the secondary with a non-inductive or dead resistance—such as incandescent lamps—whereby the time interval between the maximum or the minimum periods of the primary and secondary currents is increased. This time interval, however, is limited, and the results obtained by phase difference in the operation of such devices as my alternating-current motors can only be approximately realized by such means of producing or securing this difference, as above indicated, for it is desirable in such cases that there should exist between the primary and secondary currents, or those which, however produced, pass through the two circuits of the motor, a difference of phase of ninety degrees; or, in other words, the current in one circuit should be maximum when that in the other circuit is minimum. To more perfectly attain to this condition I obtain or secure an increased retardation of the secondary current in the following manner: Instead of bringing the primary and secondary coils or circuits of a transformer into the closest possible relations, as has hitherto been done, I protect in a measure the secondary from the inductive action or effect of the primary by surrounding either the primary or the secondary with a comparatively-thin magnetic shield or screen. Under these conditions or circumstances, as long as the primary current has a small value, the shield protects the secondary; but as soon as the primary current has reached a certain strength, which is arbitrarily determined, the protecting magnetic shield becomes saturated and the inductive action upon the secondary begins. It results, therefore, that the secondary current begins to flow at a certain fraction of a period later than it would without the interposed shield, and since this retardation may be obtained without necessarily retarding the primary current also, an additional lag is secured, and the time interval between the maximum or minimum periods of the primary and secondary currents is increased. I have further discovered that such a transformer may, by properly proportioning its several elements and determining in a manner well understood the proper relations between the primary and secondary windings, the thickness of the magnetic shield, and other conditions, be constructed to yield a constant current at all loads. No precise rules can be given for the specific construction and proportions for securing the best results, as this is a matter determined by experiment and calculation in particular cases; but the general plan of construction which I have described will be found under all conditions to conduce to the attainment of this result.

在现在和以前构造的变压器中，会发现次级的电动势与初级的电动势非常接近实时重合，但是符号相反。同时，初级电流和次级电流都落后于它们各自的电动势；但由于这种滞后在每种情况下实际上或几乎相同，初级电流和次级电流的最大值和最小值将几乎实时重合，但符号或方向不同，前提是次级没有负载或它包含具有自感特性的设备。另一方面，初级滞后于外加电动势的现象可以通过给次级加载一个非感应电阻或吸收电阻（如白炽灯）来减少，从而增加初级电流和次级电流的最大值周期或最小值周期之间的时间间隔。然而，这个时间间隔是有限的，并且在诸如我的交流电动机这样的设备的运行中通过相位差获得的结果只能通过产生或确保这种差异的这种手段来近似地实现，如上所述，因为在这种情况下，最好在初级和次级电流之间，或者在不管用什么方式产生的流经电动机的两个电路的电流之间，存在90度的相位差；或者换句话说，当一个电路中的电流最小时，另一个电路中的电流应该最大。为了更完美地达到这个条件，我以下面的方式获得或确保增加次级电流的延迟：而不是像迄今为止所做的那样使变压器的初级和次级的线圈或电路尽可能地靠近，而是通过用相对薄的磁屏蔽包围初级或次级，在一定程度上保护次级免受初级的感应效应的影响。在这些条件或情况下，只要初级电流值很小，屏蔽就会保护次级；但是一旦初级电流达到任意确定的某一强度时，磁屏蔽就会饱和，并且对次级的感应作用就会开始。因此，其结果是，次级电

流在比没有插入屏蔽时晚的某个时间段开始流动,并且由于可以在不必也延迟初级电流的情况下获得这种延迟,因此确保了额外的滞后,并且初级电流和次级电流的最大值周期或最小值周期之间的时间间隔增加。我还发现,这种变压器可以通过适当地调整其几个组件的比例并以一种很好理解的方式确定初级绕组和次级绕组之间的适当关系、磁屏蔽的厚度和其它条件,来构造成在所有负载下产生一个恒向电流。对于确保最佳结果的具体结构和比例,不能给出精确的规则,因为这是在特定情况下通过实验和计算确定的事项;但是,我所描述的总体建造方案在任何情况下都会有助于实现这一结果。

In the accompanying drawings I have illustrated the construction above set forth.

在附图中,我已经说明了上述结构。

Figure 1 is a cross-section of a transformer embodying my improvement. Fig. 2 is a similar view of a modified form of transformer, showing diagrammatically the manner of using the same.

图 1 是体现我的改进的一个变压器的横截面。图 2 是变压器的修改形式的类似视图,示意性地展示了使用该变压器的使用方式。

A A is the main core of the transformer, composed of a ring of soft annealed and insulated or oxidized iron wire. Upon this core is wound the secondary circuit or coil B B. This latter is then covered with a layer or layers of annealed and insulated iron wires C C, wound in a direction at right angles to said secondary coil. Over the whole is then wound the primary coil or wire D D. From the nature of this construction it will soon be obvious that as long as the shield formed by the wires C is below magnetic saturation the secondary coil or circuit is effectually protected or shielded from the inductive influence of the primary, although I would state that on open circuit it may exhibit some electro-motive force. When the strength of the primary reaches a certain value, the shield C, becoming saturated, ceases to protect the secondary from inductive action, and current is in consequence developed therein. For similar reasons, when the primary current weakens, the weakening of the secondary is retarded to the same or approximately the same extent.

A A 是变压器的主铁芯,由一圈软的退火的并且绝缘或氧化的铁丝组成。在这个铁芯上缠绕着次级电路或线圈 B B。然后,后者被一层或多层退火绝缘铁丝 C C 覆盖,铁丝 C C 按照与所述次级线圈成直角的方向缠绕。然后在整体上缠绕初级线圈或导线。根据这种结构的性质,很快就会明白,只要由铁丝 C 形成的屏蔽低于磁饱和,次级线圈或电路就能有效地受到保护或屏蔽,使其不受初级线圈的感应影响,尽管我认为在开路时它可以表现出一些电动势。当初级线圈的强度达到一定值时,屏蔽体 C 变得饱和,不再保护次级线圈免受感应作用,结果在次级线圈中产生电流。出于类似的原因,当初级电流减弱时,次级电流的减弱被延迟到相同或近似相同的程度。

The specific construction of the transformer is largely immaterial. In Fig. 2, for example, the core A is built up of thin insulated iron plates or disks. The primary circuit D is wound next the core A. Over this is applied the shield C, which in this case is made up of thin strips or plates of iron properly insulated and surrounding the primary, forming a closed magnetic circuit. The secondary B is wound over the shield C. In Fig. 2, also, E is a source of alternating or rapidly changing currents. The primary of the transformer is connected with the circuit of the generator.

变压器的具体结构在很大程度上无关紧要。例如，在图 2 中，铁芯 A 由薄的被绝缘的铁板或圆盘构成。初级电路 D 紧挨着铁芯 A 缠绕。在铁芯 A 上应用屏蔽层 C，在这种情况下，屏蔽层 C 由适当绝缘并包围初级电路的薄铁条或薄铁板组成，并形成一个闭合磁路。次级 B 缠绕在屏蔽层 C 上。在图 2 中，E 也是交流或快速变化电流的一个电流源。变压器的初级与发电机的电路相连。

F is a two-circuit alternating-current motor, one of the circuits being connected with the main circuit from the source E, and the other being supplied with currents from the secondary of the transformer.

F 是一台双电路交流电动机，其中一个电路从电源 E 与主电路相连，另一个电路从变压器的次级线圈获得电流。

Having now described my invention, what I claim is—

现在已经描述了我的发明，我主张的是—

1. In an electrical transformer or induction device, the combination, with the main magnetic core and the primary and secondary coils or circuits, of a magnetic shield or screen interposed between said coils, as herein set forth.

1、在一个电力变压器或感应装置中，主磁芯、初级线圈和次级线圈或次级电路与插入所述线圈之间的磁屏蔽的组合，如本文所述。

2. In an electrical transformer or inductive device, the combination, with the magnetic core and the primary and secondary coils or circuits, of a magnetic shield or screen surrounding one of said coils only, as set forth.

2、在一个电力变压器或感应装置中，磁芯、初级和次级线圈或电路与仅围绕所述线圈之一的磁屏蔽的组合，如上所述。

3. In an electrical transformer or induction device, the combination, with the magnetic core and the primary and secondary coils wound thereon, of a magnetic shield or screen wound on or built up around one only of said coils, as described.

3、在一个电力变压器或感应装置中，磁芯和缠绕在其上的初级和次级线圈的组合，一个磁屏蔽仅缠绕或建立在所述线圈其中之一上，如上所述。

4. In an electrical transformer or induction device, the combination, with a main laminated magnetic core and primary and secondary coils thereon, of a subdivided or laminated magnetic shield or screen interposed between the coils, as set forth.

4、在一个电力变压器或感应装置中，一个主叠片磁芯及其上的初级和次级线圈与插入线圈之间的细分的或叠片的磁屏蔽的组合，如前所述。

5. In an electrical transformer, the combination, with a magnetic core and primary and secondary coil

wound thereon, of a magnetic shield or screen interposed between said coils and surrounding one of them and adapted to be or capable of being magnetically saturated by a predetermined current strength below the maximum in the primary, as set forth.

5、在一个电力变压器或感应装置中，一个磁芯和缠绕在其上的初级和次级线圈以及一个磁屏蔽的组合，该磁屏蔽插入在所述线圈之间并包围它们中的一种，并且适于或能够被低于初级中最大值的一个预定电流强度所磁饱和，如前所述。

NIKOLA TESLA.

尼古拉·特斯拉

Witnesses:

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PARKER W. PAGE

见证人:

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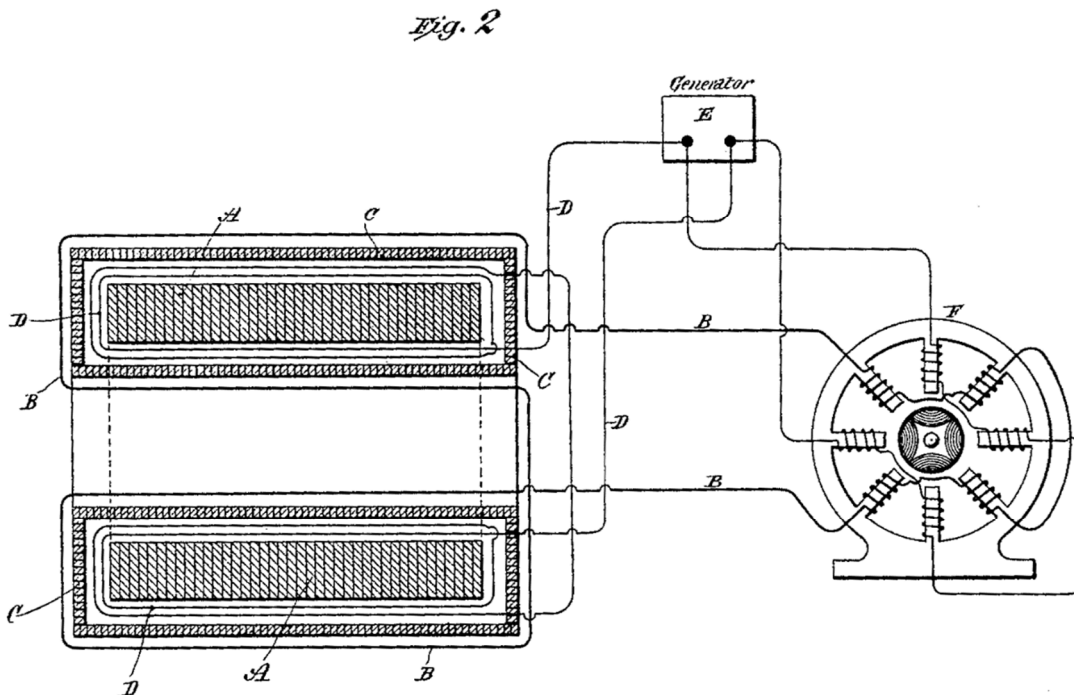
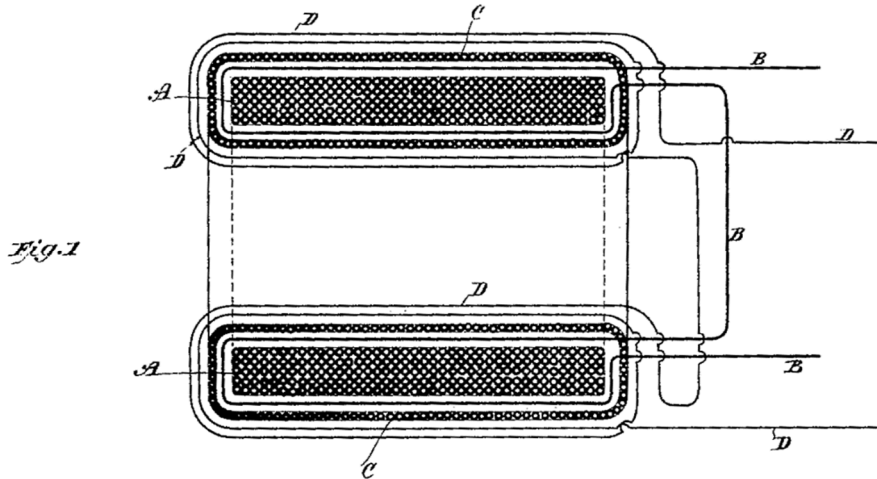
(No Model.)

N. TESLA.

ELECTRICAL TRANSFORMER OR INDUCTION DEVICE.

No. 433,702.

Patented Aug. 5, 1890.



Witnesses:
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Ernest Hutchinson

Inventor
Nikola Tesla
by
Duncan, Curtis & Page
Attorneys.

ELECTRO-MAGNETIC MOTOR.

电磁电动机

NIKOLA TESLA, OF NEW YORK, N. Y., ASSIGNOR TO THE TESLA ELECTRIC
COMPANY, OF SAME PLACE.

纽约州纽约市的尼古拉·特斯拉将专利权转让给纽约市的特斯拉电气公司。

SPECIFICATION forming part of Letters Patent No. 433,703, dated August 5, 1890.

Application filed April 4, 1890. Serial No. 346,603. (No model.)

该说明书形成了颁发于 1890 年 8 月 5 日编号为 433,703 的专利证书的一部分。

申请于 1890 年 4 月 4 日提交。序列号为 346,603。(没有模型)

To all whom it may concern:

致所有相关人士:

Be it known that I, NIKOLA TESLA, a subject of the Emperor of Austria-Hungary, from Smiljan, Lika, border country of Austria-Hungary, residing at New York, in the county and State of New York, have invented certain new and useful Improvements in Electro-Magnetic Motors, of which the following is a specification, reference being had to the drawings accompanying and forming a part of the same.

众所周知,我、尼古拉·特斯拉、一位奥匈帝国的臣民,来自奥匈帝国边境地区的利卡县的史密里安村,现在居住在纽约州纽约郡纽约市,在电磁电动机方面已经发明了某种新的和有用的改进,以下是该发明一个说明书,必须参考随附的图纸,它已形成该说明书的一部分。

This invention is an improvement in alternating-current motors, and has for its general object to produce a single-circuit alternating current torque-motor of economical and simple construction.

本发明是对交流电动机的改进,其总的目的是生产一种具有经济的和简单的结构的单电路交流转矩电动机。

The nature of the invention will be understood from the following statement.

从下面的陈述中可以理解本发明的本质。

It is well known that if a magnetic core, even if laminated or subdivided, be wound with an insulated coil and a current of electricity directed through the coil the magnetization of the entire core does not immediately ensue, the magnetizing effect not being exhibited in all parts simultaneously. This I attribute to the fact that the action of the current is to energize first those laminae or parts of the core nearest the surface of and adjacent to the exciting-coil, and from thence the action progresses toward the interior. A certain interval of time therefore elapses between the manifestation of magnetism in the external and the internal sections or layers of the core. If the core be thin or of small mass, this effect

may be inappreciable; but in the case of a thick core, or even of a comparatively thin one, if the number of alternation or rate of change of the current strength be very great the time interval occurring between the manifestations of magnetism in the interior of the core and in those parts adjacent to the coil is more marked, and in the construction of such apparatus as motors which are designed to be run by alternating or equivalent currents—such as pulsating or undulating currents generally—I have found it desirable and even necessary to give due consideration to this phenomenon and to make special provisions in order to obviate its consequences. The specific object of my present invention is to take advantage of this action or effect, and by rendering it more pronounced to utilize it in the operation of motors in general. This object I attain by constructing a field-magnet in which the parts of the core or cores that exhibit at different intervals of time the magnetic effect imparted to them by alternating or equivalent currents in an energizing coil or coils are so placed with relation to a rotating armature as to exert thereon their attractive effect successively in the order of their magnetization. By this means I secure a similar result to that which I have heretofore attained in other forms or types of motor in which by means of one or more alternating currents I have produced a rotation or progression of the magnetic poles or points of maximum attraction of the field of force.

众所周知，如果一个磁芯（即使是叠片的或细分的）缠绕有绝缘线圈，并且电流直接通过该线圈，整个铁芯的磁化不会立即发生，磁化效果不会在所有部分同时呈现。我将此归因于这样一个事实，即电流的作用是首先励磁那些靠着励磁线圈表面最近的铁芯的那些薄片或部分，然后作用从那里向内部进行。因此，在铁芯的外部 and 内部的部分或叠层的磁性显现之间，会有一定的时间间隔。如果铁芯很薄或质量很小，这种影响可能是微不足道的；但是在粗铁芯的情况下，或者甚至在相对较薄的铁芯的情况下，如果电流强度的交替次数或变化速率非常大，则在铁芯的内部和靠近线圈的那些部分的磁性表现之间的时间间隔更显著，在这种装置的构造中，例如设计成由交流或等效电流（例如通常的脉动或波动电流）运行的电动机——我发现适当考虑这种现象并做出特殊配置以避免其后果是可取的，甚至是必要的。本发明的具体目的是利用这种作用或效果，并使其更明显地应用于一般电动机的运行中。这个目的是通过构造一种场磁体来实现的，在该场磁体中，一个或多个铁芯的各个部分以不同的时间间隔表现出由一个（或多个）励磁线圈中的交变或等效电流所赋予它们的磁效应，这些线圈相对于旋转电枢这样放置，以便按照它们的磁化顺序连续地在旋转电枢上施加它们的吸引效应。通过这种方法，我确保了一个类似于我迄今为止用其他形式或类型的电动机得到的结果，在所谓的其他形式的电动机中，我通过一个或多个交流电流已经产生了磁极或磁场的最大吸引力点的旋转或前进。

In the drawings I have shown a simple form of motor, which will serve to demonstrate the principle of the mode of operation, which I have above described in general terms.

在附图中，我已经展示了电动机的简单形式，其将用于展示操作模式的原理，我已经在上面概括地描述了该运行模式的原理。

Figure 1 is a side elevation of such motor. Fig. 2 is a side elevation of a more practicable and efficient embodiment of the invention. Fig. 3 is a central vertical section of the same in the plane of the axis of rotation.

图1是这种电动机的侧视图。图2是本发明的更实用和更有效的实施例的侧视图。图3是该发明的在旋转轴平面中的中心垂直截面图。

Referring to Fig. 1, let X represent a large iron core, which may be composed of a number of sheets or laminae of soft iron or steel. Surrounding this core is a coil Y, which is connected with a source E of rapidly-varying currents. Let us consider now the magnetic conditions existing in this core at any point as b, at or near the center, and any other point, as a, nearer the surface. When a current-impulse is started in the magnetizing-coil Y, the section or part a, being close to the coil, is immediately energized, while the section or part at b, which, to use a convenient expression, is “protected” by the intervening sections or layers between a and b, does not at once exhibit magnetism. However, as the magnetization of a increases, b becomes also affected, reaching finally its maximum strength some time later than a. Upon the weakening of the current the magnetization of a first diminishes, while b still exhibits its maximum strength; but the continued weakening of a is attended by a subsequent weakening of b. Assuming the current to be an alternating one, a will now be reversed, while b still continues of the first-imparted polarity. This action continues the magnetic condition of b, following that of a in the manner above described. If an armature—for instance, a simple disk F, mounted to rotate freely on an axis—be brought into proximity to the core, a movement of rotation will be imparted to the disk, the direction depending upon its position relatively to the core, the tendency being to turn the portion of the disk nearest to the core from a to b, as indicated in Fig. 1. This action or principle of operation I have embodied in a practicable form of motor, which is illustrated in Fig. 2. Let A in said figure represent a circular frame of iron, from diametrically-opposite points of the interior of which the cores project. Each core is composed of three main parts B, B, and C, and they are similarly formed with a straight portion or body e, around which the energizing-coil is wound, a curved arm or extension c, and an inwardly-projecting pole or end d. Each core is made up of two parts B B, with their polar extensions reaching in one direction and a part C between the other two and with its polar extension reaching in the opposite direction. In order to lessen in the cores the circulation of currents induced therein, the several sections are insulated from one another in the manner usually followed in such cases. These cores are wound with coils D, which are connected in the same circuit, either in parallel or series, and supplied with an alternating or a pulsating current, preferably the former, by a generator E, represented diagrammatically. Between the cores or their polar extensions is mounted a cylindrical or similar armature F, wound with magnetizing-coils G, that are closed upon themselves, as is usual in motors of this general class.

参见图 1，设 X 代表一个大铁芯，它可以由许多软铁或钢的叠片或薄片组成。围绕这个铁芯的是一个线圈 Y，它与一个快速变化的电流源 E 相连。现在让我们考虑铁芯中任何一点的磁场条件，比如 b 点在中心或中心附近，而另一点，比如 a 点，则靠近表面。当一个电流脉冲在磁化线圈 Y 中开始时，靠近线圈的 a 部分立即被励磁，而在 b 处的部分，用一个方便的表达，被 a 和 b 之间的介入部分或层“保护”了，不能立即表现出磁性。然而，当 a 的磁化强度增加时，b 也会受到影响，比 a 晚一段时间达到最大强度。当电流减弱时，a 的磁化强度减弱，而 b 的磁化强度仍然达到最大；但是 a 的持续减弱，随后是 b 的随后减弱。假设电流是交变电流，a 现在将被反转，而 b 仍然保持最初赋予的极性。这个动作延续了 b 的磁性状态，以上述方式跟随 a 的磁性状态。如果一个电枢——例如，安装在一个轴上自由旋转的简单圆盘 F——靠近铁芯，圆盘将产生旋转运动，旋转方向取决于它相对于铁芯的位置，其趋势是将圆盘最靠近铁芯的部分从 a 转到 b，如图 1 所示。这种作用或运行原理体现在图 2 所示的一种可行形式的电动机中。让所述图中的 A 代表一个圆形铁框架，从其内部的径向相对的点向铁芯突出。每个铁芯由三个主要部分 B、B 和 C 组成，并且它们类似地由有一个直的部分或主体 e、一个弯曲的臂或延伸部分 c 以及向内突出的极或端部 d 所形成，励磁线圈缠绕在上述直的部分或主体 e 上。每个铁芯由两个部分 B B 组成，它们的极性延伸是在一个

方向上，而部分 C 位于另外两个部件之间，它的极性延伸是在相反的方向上。为了减少铁芯中感应电流的循环，几个部分在这种情况下以通常遵循的方式彼此绝缘。这些铁芯上缠绕有线圈 D，这些线圈并联或串联连接在同一电路中，并由交流或脉动电流供电，如图所示，最好是发电机 E 提供的交流电流。在铁芯或其极性延伸部分之间安装有一个圆柱形或类似的电枢 F，上面缠绕有磁化线圈 G，这些线圈自身闭合，这在这种普遍类型的电动机中是常见的。

The operation of this motor is as follows: When a current impulse or alternation is directed through the coils D, the sections B B of the cores, being on the surface and in close proximity to the coils, are immediately energized. The sections C, on the other hand, are protected from the magnetizing influence of the coil by the interposed layers of iron B B. As the magnetism of B B increases, however, the sections C are also energized; but they do not attain their maximum strength until a certain time subsequent to the exhibition by the sections B B of their maximum. Upon the weakening of the current the magnetic strength of B B first diminishes, while the sections C have still their maximum strength; but as B B continue to weaken the interior sections are similarly weakened. B B may then begin to exhibit an opposite polarity, which is followed later by a similar change on C, and this action continues. B B and C may therefore be considered as separate field-magnets, being extended so as to act on the armature in the most efficient positions, and the effect is similar to that in my other forms of motor—viz., a rotation or progression of the maximum points of the field of force. Any armature—such, for instance, as a disk—mounted in this field would rotate from the pole first to exhibit its magnetism to that which exhibits it later.

该电动机的运行如下:当一个电流脉冲或交变电流被引导通过线圈 D 时，位于表面上且非常靠近线圈的铁芯部分 B B 立即被励磁。另一方面，部件 C 被插入的铁质部分 B B 保护免受线圈磁化的影响。然而，随着 B B 的磁性增加，部分 C 也被激励；但它们没有达到它们的最大强度，直到部分 B B 表现了自身的最大强度后的一段时间后，部分 C 才表现出自身的最大强度。当电流减弱时，部分 B B 的磁场强度首先减弱，而部分 C 仍然具有最大强度；但是随着 B B 继续减弱，内部部件也同样减弱。然后 B B 可能开始表现出一个相反的极性，随后 C 也发生类似的变化，这个过程一直持续下去。因此，B B 和 C 可以被认为是分开的场磁体，它们被延伸以在最有效的位置上作用于电枢，效果类似于我的其他形式的电动机——即力场的最大点的旋转或前进。任何安装在这个磁场中的电枢——例如一个圆盘——都会从最先表现磁性的磁极旋转到随后表现磁性的磁极。

It is evident that the principle herein described may be carried out in conjunction with other means, such as I have elsewhere set forth, for securing a more favorable or efficient action of the motor. For example, the polar extensions of the sections C may be wound or surrounded by closed coils L, as indicated by dotted lines in Fig. 2. The effect of these coils will be to still more effectively retard the magnetization of the polar extensions of C.

很明显，这里描述的原理可以结合其他装置来实现，例如我在别处提到的用于确保电动机的更有利或更有效的动作的装置。例如，部分 C 的极性延伸可以由闭合线圈 L 缠绕或环绕，如图 2 中虚线所示。这些线圈的作用将是更有效地延迟 C 的极性延伸的磁化。

I do not wish to be understood as limiting myself to any particular construction of this form of motor, as the same principle of action or operation may be carried out in a great variety of forms.

我不希望被理解为将我自己限制于这种形式的电动机的任何特定构造,因为相同的作用或运行原理可以以多种形式执行。

What I claim is—

我主张的是—

1. In an alternating-current motor, the combination, with an energizing-coil and a core composed of two parts, one protected from magnetization by the other interposed between it and the coil, of an armature mounted with the influence of the fields of force produced by said parts, as set forth.

1、在一个交流电动机中,存在一个组合,它包括一个励磁线圈、一个铁芯和一个电枢。该铁芯由两个部件组成,其中一个部件由插入它和线圈之间的另一个部件保护免于被磁化,该电枢被安装在所述部件的力场的影响下,如上所述。

2. The combination, in an alternating-current motor, of a rotating armature, a field-magnet composed of a coil and a core with two sections in proximity to the coil and an inner section between the same, the sections being formed or provided with polar projections extending in opposite directions over or around the armature, as set forth.

2、在一个交流电动机中,存在一个组合,它包括一个旋转电枢和一个场磁体。该场磁体由一个线圈和一个铁芯构成,该铁芯有两个部件靠近线圈,有一个内部部件在这两个部件之间,这些部件形成极突或配有极突,这些突起围绕着电枢并在相反方向上延伸,如上所述。

3. The combination, in an alternating-current motor, of a rotating armature, a frame and field-magnets thereon, each composed of an energizing-coil wound around a core made up of outer and inner or protected magnetic sections, each of which is formed or provided with independent laterally-extended pole pieces or projections, as herein described.

3、在一个交流电动机中,存在一个组合,它包括一个旋转电枢、一个框架和在该框架上的场磁体,每一个场磁体都由缠绕着一个铁芯的一个励磁线圈组成,该铁芯由外部部件和内部部件(或者被磁保护的部件)组成,每一个部件都形成或配有独立的横向延伸的极靴或突起,如本文所述。

NIKOLA TESLA.

尼古拉·特斯拉

Witnesses:

ROBT. F. GAYLORD,

PARKER W. PAGE.

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(No Model.)

N. TESLA.
ELECTRO MAGNETIC MOTOR.

No. 433,703.

Patented Aug. 5, 1890.

Fig. 1

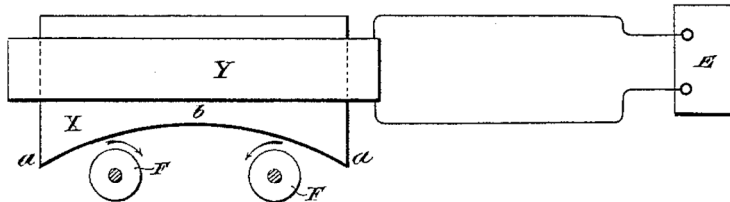


Fig. 2

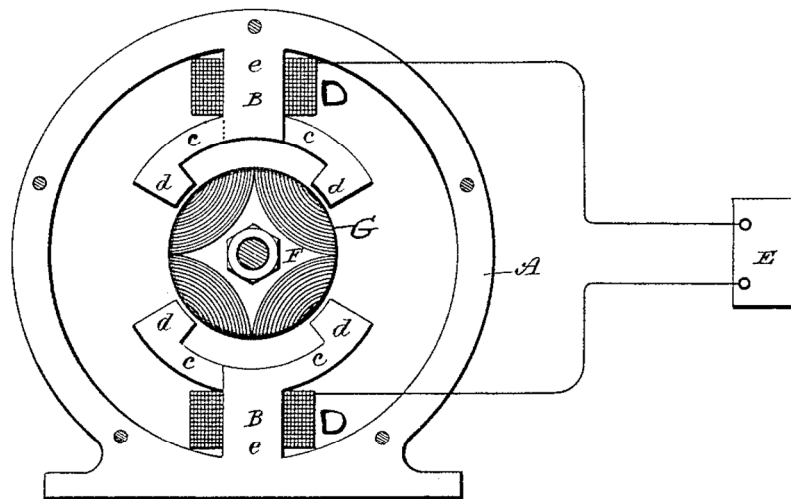
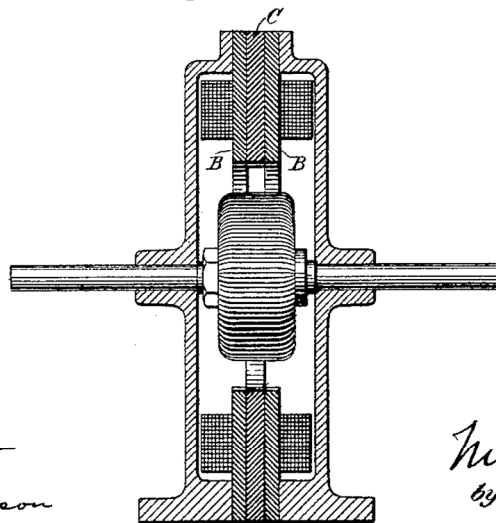


Fig. 3



Witnesses:

Raphael Netter
Ernest Loptinson

Inventor

Nikola Tesla

by

Duncan, Curtis & Page
Attorneys.

ELECTRO-MAGNETIC MOTOR.

电磁电动机

NIKOLA TESLA, OF NEW YORK, N. Y., ASSIGNOR TO THE TESLA ELECTRIC
COMPANY, OF SAME PLACE.

纽约州纽约市的尼古拉·特斯拉将专利权转让给纽约市的特斯拉电气公司。

SPECIFICATION forming part of Letters Patent No. 445,207, dated January 27, 1891.

Application filed May 20, 1889. Serial No. 311,417. (No model.)

该说明书形成了颁发于 1891 年 1 月 27 日编号为 445,207 的专利证书的一部分。

申请于 1889 年 5 月 20 日提交。序列号为 311,417。(没有模型)

To all whom it may concern:

致所有相关人士:

Be it known that I, NIKOLA TESLA, a subject of the Emperor of Austria-Hungary, from Smiljan, Lika, border country of Austria-Hungary, residing at New York, in the county and State of New York, have invented certain new and useful Improvements in Electro-Magnetic Motors, of which the following is a specification, reference being had to the drawings accompanying and forming a part of the same.

众所周知，我、尼古拉·特斯拉、一位奥匈帝国的臣民，来自奥匈帝国边境地区的利卡县的史密里安村，现在居住在纽约州纽约郡纽约市，在电磁电动机方面已经发明了某种新的和有用的改进，以下是该发明一个说明书，必须参考随附的图纸，它已形成该说明书的一部分。

Among the various forms of alternating-current motors invented by me is one which I have described in other applications, and which is constructed as follows: I build a field-core with, say, four poles, between which is mounted an armature that is generally wound with closed coils. On two of the opposite poles of the field I wind primary coils, which are connected up in the main circuit. On the same cores I also wind secondary coils, which are closed through coils on the other pair or set of poles. but the phases of the current in the secondary coils may differ in time from those of the primary current, and hence a rotation or shifting of the poles is effected that imparts rotation to the motor.

在我发明的各种形式的交流电动机中，有一种是我在其他应用中描述过的，其结构如下：我建造了一个有四个磁极的磁场铁芯，磁极之间安装了一个电枢，通常缠绕着闭合线圈。在磁场的相反两极，我缠绕初级线圈，它们在主电路中被连接起来。在上述铁芯上，我还缠绕了次级线圈，次级线圈通过另一对或另一组磁极上的线圈闭合。在这种电动机中，当一个交流电通过初级线圈时，它直接励磁一组磁极，并在次级线圈中感应出电流，次级线圈励磁其他磁极；但是次级线圈中电流的相位可以在时间上不同于初级电流的相位，因此实现了磁极的旋转或转移，从而将旋转传递给电动机。

These motors may be constructed in many other ways; but for purposes of this case it is only necessary to consider the specific form which I have thus generally described, as my improvements relate mainly to such form.

这些电动机可以用许多其他方式构建；但是对于本实例的目的，只需要考虑我因此概括描述的特定形式，因为我的改进主要涉及这样的形式。

The object of my present invention is to render this form of motor more efficient and to improve its action or mode of operation.

本发明的目的是使这种形式的电动机更加有效，并改进其动作或运行模式。

In the motors constructed in accordance with this principle I bring two energizing-circuits into inductive relation in the motor itself—that is to say, the secondary currents which energize one set of the field-cores are induced in the motor itself, and the employment of an external induction device is thus avoided. The operation of these motors, however, is dependent upon the existence of a certain difference of phase between the currents in the primary and secondary coils. To obtain a difference of phase or lag that is suited to working conditions is the specific object of my present invention.

在根据该原理构建的电动机中，我使得两个励磁电路在电动机本身中形成感应关系——也就是说，励磁一组励磁铁芯的次级电流在电动机本身中被感应产生，因此避免了一个外部感应装置的使用。然而，这些电动机的运行依赖于初级线圈和次级线圈中的电流之间存在一定的相位差。获得适合于工作条件的相位差或滞后是我的发明的具体目的。

The following explanations will serve to illustrate the principle upon which said invention is based. Let it be assumed that an ordinary alternating-current generator is connected up in a circuit of practically no self-induction, such, for example, as a circuit containing incandescent lamps only. On the operation of the machine alternating currents will be developed in the circuit, and the phases of these currents will theoretically coincide with the phases of the impressed electro-motive force. Such currents may be regarded and designated as the “unretarded currents.”

以下解释将用于说明所述发明基于的原理。假设一个普通的交流发电机连接在一个实际上没有自感应的电路中，例如，一个只包含白炽灯的电路。在机器运行时，电路中将产生交流电，这些电流的相位在理论上与外加电动势的相位一致。这种电流可以被认为是“未被延迟的电流”。

It will be understood, of course, that in practice there is always more or less self-induction in the circuit, which modifies to a corresponding extent these conditions; but for convenience this may be disregarded in the consideration of the principle of operation, since the same laws apply. Assume next that a path of currents be formed across any two points of the above circuit, consisting, for example, of the primary of an induction device. The phases of the currents passing through the primary, owing to the self-induction of the same, will not coincide with the phases of the impressed electro-motive force, but will lag behind the same, such lag being directly proportional to the self-induction and inversely proportional to the resistance of the said coil. The insertion of this coil will also cause a lagging or retardation of the currents traversing and delivered by the generator behind the impressed electro-motive force, such lag

being the mean or resultant of the lag of the current through the primary alone and that of what I have designated the “unretarded current” in the entire working-circuit. Next consider the conditions imposed by the association in inductive relation with the primary coil of a secondary coil. The current generated in the secondary coil will react upon the primary current, modifying the retardation of the same, according to the amount of self-induction and resistance in the secondary circuit. If the secondary circuit have but little self-induction—as, for instance, when it contains incandescent lamps only—it will increase the actual difference of phase between its own and the primary current, first, by diminishing the lag between the primary current and the impressed electro-motive force, and, second, by its own lag or retardation behind the impressed electro-motive force. On the other hand, if the secondary circuit have a high self-induction its lag behind the current in the primary is directly increased, while it will be still further increased if the primary have a very low self-induction. The better results are obtained when the primary has a low self-induction. I apply these principles to the construction of a motor which I shall now describe.

当然，应该理解，在实践中，电路中总是存在或多或少的自感，这种自感在相应程度上改变了这些条件；但是为了方便起见，在考虑运行原理时可以忽略这一点，因为同样的规律适用。接下来假设在上述电路的任意两点之间形成一条电流通路，例如，该电路由一个感应装置的初级线圈组成。由于初级线圈的自感，流过初级线圈的电流的相位将不与外加电动势的相位一致，而是滞后于该相位，这种滞后与自感成正比，与所述线圈的电阻成反比。该线圈的插入也会导致正在流过发电机、以及正被发电机输送的电流出现相对外加电动势的延迟或滞后，这种滞后是仅流经初级的电流的滞后和整个工作电路中“未被延迟的电流”的平均值或合成结果。接下来，考虑次级线圈与初级线圈的感应关系所施加的条件。次级线圈中产生的电流将对初级电流起反作用，根据次级电路中的自感应和电阻的量来改变初级电流的延迟。如果次级电路只有很少的自感，例如，当它只包含白炽灯时，它将增加其自身和初级电流之间的实际相位差，首先，是通过减小初级电流和外加电动势之间的滞后，其次，是通过它的外加电动势之后的滞后或延迟。另一方面，如果次级电路具有高的自感，它的落后于初级电路中的电流的滞后直接增加，而如果初级具有非常低的自感，该滞后将进一步增加。当初级线圈具有低自感时，可以获得更好的结果。我把这些原理应用到我现在将要描述的电动机的结构中。

The details of the improvements are illustrated in the drawings, in which—

改进的细节在附图中说明，其中—

Figure 1 is a diagram of a motor exhibiting my invention. Fig. 2 is a similar diagram of a modification of the same.

图 1 是展示我的发明的电动机的示意图。图 2 是对其进行修改的类似示意图。

In Fig. 1 let A designate the field-magnet of a motor which, as in all these motors, is built up of sections or plates. B C are polar projections upon which the coils are wound. Upon one pair of these poles, as C, I wind primary coils D, which are directly connected to the circuit of an alternating-current generator G. On the same poles I also wind secondary coils F, either side by side or over or under the primary coils, and these I connect with other coils E, which surround the poles B B. The currents in both primary and secondary coils in such a motor will be retarded or will lag behind the impressed electro-

motive force; but to secure a proper difference in phase between the primary and secondary currents themselves I increase the resistance of the circuit of the secondary and reduce as much as practicable its self-induction. I do this by using for the secondary circuit, particularly in the coils E, wire of comparatively small diameter and having but few turns around the cores; or I use some conductor of higher specific resistance, such as German silver; or I may introduce at some point in the secondary circuit an artificial resistance R. Thus the self-induction of the secondary is kept down and its resistance increased with the result of decreasing the lag between the impressed electro-motive force and the current in the primary coils and increasing the difference of phase between the primary and secondary currents.

在图 1 中，用 A 表示一台电动机的磁场体，和所有这些电动机一样，它是由几个部分或几块板组成的。B C 是自身缠绕线圈的磁极突起。在这些磁极中的一对磁极上，如 C，我在 C 上缠绕初级线圈 D，D 直接连接到交流发电机 G 的电路。在相同的磁极上，我也缠绕了次级线圈 F，或者与初级线圈并排或者在初级线圈之上或之下，并且这些线圈与围绕磁极 B B 的其他线圈 E 连接。这种电动机的初级线圈和次级线圈中的电流将被延迟或滞后于所施加的电动势；但是为了确保初级电流和次级电流本身之间的适当相位差，我增加了次级电路的电阻，并尽可能多地降低其自感。我通过使用次级电路，特别是在线圈 E 中，利用直径相对较小的且围绕铁芯的匝数很少的导线来实现这一点；或者我用一些电阻率更高的导体，比如锌白铜；或者我可以在次级电路的某个点引入一个仿真电阻 R。因此，次级线圈的自感被抑制，其电阻增加，结果是减小了外加电动势和初级线圈中的电流之间的滞后，并增加了初级电流和次级电流之间的相位差。

In the disposition shown in Fig. 2 the lag in the secondary is increased by increasing the self-induction of that circuit, while the increased tendency of the primary to lag is counteracted by inserting therein a dead resistance. The primary coils D in this case have a low self-induction and high resistance, while the coils E F, included in the secondary circuit, have a high self-induction and low resistance. This may be done by the proper winding of the coils, or in the circuit including the secondary coils E F, I may introduce a self-induction coil S, while in the primary circuit from the generator G and including coils D, I may insert a dead resistance R. By this means the difference of phase between the primary and secondary is increased. It is evident that both means of increasing the difference of phase—namely, by the special winding as well as by the supplemental or external inductive and dead resistance—may be employed conjointly.

在图 2 所示的布置中，次级电路中的滞后是通过增加该电路的自感来增加的，而初级电路中滞后趋势的增加是通过在其中接入一个吸收电阻来抵消。在这种情况下，初级线圈 D 具有低自感和高电阻，而包含在次级电路中的线圈 EF 具有高自感和低电阻。这可以通过线圈的适当缠绕来实现，或者在包含次级线圈 EF 的电路中，我可以引入一个自感线圈 S，而在来自发电机 G 并包括线圈 D 的初级电路中，我可以插入一个吸收电阻 R。通过这种方式，初级和次级之间的相位差增加了。显然，增加相位差的两种方法——即通过特殊绕组以及补充的或外部的电感和吸收电阻——可以结合使用。

In the operation of this motor the current impulses in the primary coils induce currents in the secondary coils, and by the conjoint action of the two the points of greatest magnetic attraction are shifted or rotated.

在该电动机的运行中，初级线圈中的电流脉冲在次级线圈中感应出电流，并且通过两者的联合作用，最大磁吸引点被转移或旋转。

In practice I have found it desirable to wind the armature with closed coils in which currents are induced by the action thereon of the primaries.

在实践中，我发现用闭合线圈缠绕电枢是可取的，在闭合线圈中，通过初级线圈在闭合线圈上的作用能感应出电流。

I do not claim, broadly, herein the method of operating motors by inducing in one circuit currents by means of those in another, nor the other features herein not specifically pointed out in the claims, having personally filed applications for such features.

从广义上讲，我在这里没有主张在一个电路中利用另一个电路的施感电流来运行电动机的方法，也没有主张未被具体指出的其他特征，已经个人提交了对这些特征的申请。

What I claim is—

我主张的是—

1. The combination, in a motor, of a primary energizing-circuit adapted to be connected with the circuit of a generator and a secondary energizing-circuit in inductive relation thereto, the two circuits being of different electrical character or resistance, as set forth.

1、在一个电动机中，适于与发电机的电路连接的初级励磁电路和与其成感应关系的次级励磁电路的组合，这两个电路具有不同的电特性或电阻，如上所述。

2. The combination, in a motor, of a primary energizing-coils adapted to be connected with the circuit of a generator and a secondary energizing-circuit in inductive relation thereto, the two circuits being of different self-induction, as herein set forth.

2、在一个电动机中，初级励磁线圈和次级励磁电路的组合，初级激励线圈适于与一个发电机的电路连接，次级激励电路与该发电机的电路成感应关系，这两个电路具有不同的自感，如本文所述。

3. The combination, in a motor, of primary energizing-coils adapted to be connected to a source of current and secondary energizing-coils in a circuit in inductive relation thereto, one set of said coils being formed by conductors of small size and few turns, the other by conductors of larger size, as set forth.

3、在一个电动机中，适于连接到电流源的初级励磁线圈和电路中与其成感应关系的次级激励线圈的组合，一组所述线圈由小尺寸和少匝数的导体形成，另一组由较大尺寸的导体形成，如上所述。

NIKOLA TESLA.

尼古拉·特斯拉

Witnesses:

R. J. STONEY, Jr.,

E. P. COFFIN.

见证人：R. J. 斯托尼、E. P. 考芬。

(No Model.)

N. TESLA.
ELECTRO MAGNETIC MOTOR.

No. 445,207.

Patented Jan. 27, 1891.

Fig. 1

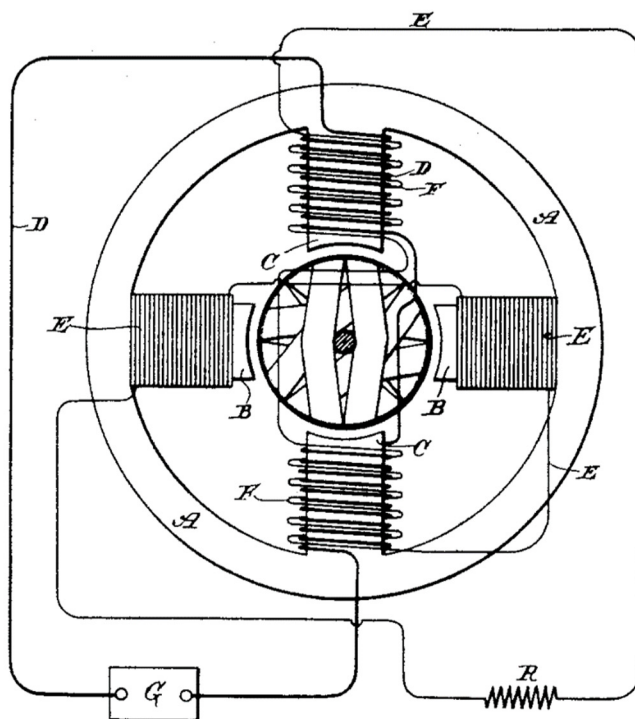
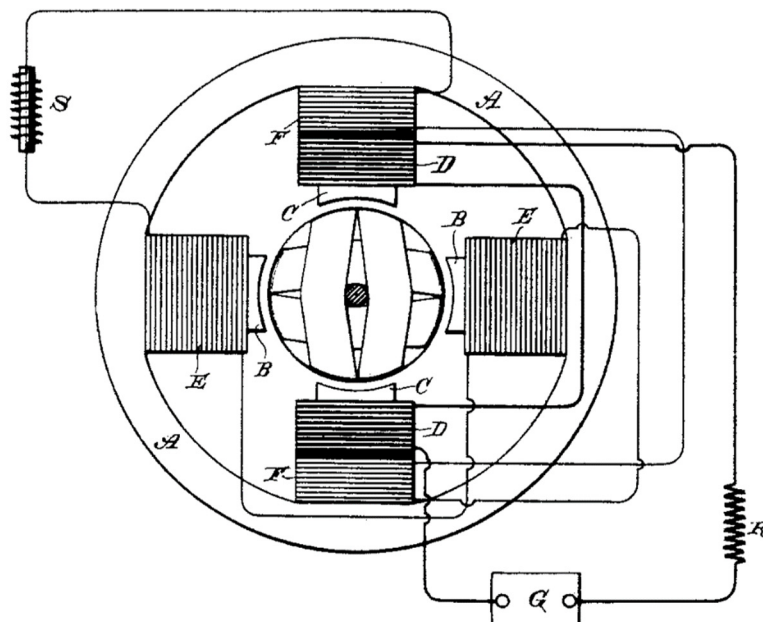


Fig. 2



Witnesses:
Raphael Weller
Frank & Hartley

Inventor
Nikola Tesla
By
Duncan, Curtis & Page,
Attorneys.

ALTERNATING-ELECTRIC-CURRENT GENERATOR.

交流电发电机

NIKOLA TESLA, OF NEW YORK, N. Y.

纽约州纽约市的尼古拉·特斯拉

SPECIFICATION forming part of Letters Patent No. 447,921, dated March 10, 1891.

Application filed November 15, 1890. Serial No. 371,554. (No model.)

该说明书形成了颁发于 1891 年 3 月 10 日编号为 447,921 的专利证书的一部分。

申请于 1890 年 11 月 15 日提交。序列号为 371,554。(没有模型)

To all whom it may concern:

致所有相关人士:

Be it known that I, NIKOLA TESLA, a subject of the Emperor of Austria, from Smiljan, Lika, border country of Austria-Hungary, residing at New York, in the county and State of New York, have invented certain new and useful Improvements in Alternating-Current Machines, of which the following is a specification, reference being had to the accompanying drawings.

众所周知，我、尼古拉·特斯拉、一位奥匈帝国的臣民，来自奥匈帝国边境地区的利卡县的史密里安村，现在居住在纽约州纽约郡纽约市，在交流电机方面已经发明了某种新的和有用的改进，以下是该发明一个说明书，必须参考随附的图纸。

In the systems of distribution of electrical energy from alternating-current generators in present use the generators give ordinarily from one to three hundred alternations of current per second. I have recognized and demonstrated in practice that it is of great advantage, on many accounts, to employ in such systems generators capable of producing a very much greater number of alternations per second—say fifteen thousand per second or many more. To produce such a high rate of alternation, it is necessary to construct a machine with a great number of poles or polar projections; but such construction, on this account, in order to be efficient, is rendered difficult. If an armature without polar projections be used, it is not easy to obtain the necessary strength of field, mainly in consequence of the comparatively great leakage of the lines of force from pole to pole. If, on the contrary, an armature-core formed or provided with polar projections be employed, it is evident that a limit is soon reached at which the iron is not economically utilized, being incapable of following without considerable loss the rapid reversals of polarity. To obviate these and other difficulties, I have devised a form of machine embodying the following general features of construction.

在目前使用的来自交流发电机的电能分配系统中，发电机通常每秒产生一百到三百次交变电流。我已经认识到并在实践中证明，在许多情况下，在这样的系统中使用能够每秒产生非常

多的交变次数的发电机是非常有利的——比方说每秒一万五千次或更多。为了产生如此高的交替率，有必要构造一种具有大量磁极或极性突起的机器；但是由于这个原因，为了有效，这样的构造变得困难。如果电枢不具有可以使用的极性突起，就会难以获得必要的磁场强度，主要是由于存在从磁极到磁极的比较大的磁力线泄漏。相反，如果采用形成有或配有极性突起的电枢铁芯，很明显，很快就会达到了一个极限，在这个极限，铁芯不能被经济地利用，不能够在没有相当大的能量损失的情况下跟随极性的快速反转。为了避免这些困难和其他困难，我设计了一种体现以下总体结构特征的机器形式。

I provide a field-magnet core made up of two independent parts formed with grooves for the reception of one or more energizing-coils. The energizing coil, or coils, is completely surrounded by the iron core, except on one side, where occurs the opening between the polar faces of the core, which opening is made as narrow as the conditions of the machine will permit. The polar faces of the core of the field are not smooth, but formed with a great many projections or serrations, the points of which is one side or polar face are preferably exactly opposite those in the other. Between the faces so formed I mount or support the armature coil or coils and provide either for rotating the field-magnet or the armature, or both, and I arrange the said armature-coil or conductor so that it will be symmetrically disposed with respect to the field—that is to say, so that when one portion of the conductor is passing through the strongest portion of the field the other portion, which forms the return for the former, is passing through the weakest points or parts of the field. The strongest points of the field, it will be understood, are those between the projections or points on the polar faces, while the weakest points lie midway between them.

我提供了一种由两个独立部件组成的场铁芯，这两个独立部件形成有利于容纳一个或多个励磁线圈的凹槽。一个或多个励磁线圈完全被铁芯包围，除了在铁芯的极面之间出现开口的一侧，该开口在机器条件允许的情况下尽可能地窄。磁场铁芯的极面不是光滑的，而是形成有许多突起或锯齿，其一侧或极面的点最好与另一侧的点完全相反。在如此形成的面之间，我安装或支撑一个或两个电枢线圈，并且为其中一个线圈或者这两个线圈供电用来旋转场磁体或电枢，并且我布置所述电枢线圈或导体，使得它相对于磁场对称地布置——也就是说，使得当导体的一部分正在穿过磁场的最强部分时，形成前者的回路的另一部分正在穿过磁场的最弱部分。可以理解，磁场的最强点是那些位于极面上的各突起之间的点，而最弱点位于它们（最强点）之间的中点。

A field-magnet, when constructed as above described, produces, when the energizing-coil is traversed by a continuous current, a field of great strength, and one which may be made to vary greatly in intensity at points not farther distant from one another than the eighth of an inch. In a machine thus constructed there is comparatively little of that effect which is known as “magnetic leakage,” and there is also but a slight armature reaction.

如上所述构造的一个场磁铁，当励磁线圈被一个恒向电流流过时，会产生一个强度很大的场，并且可以在彼此相距不超过八分之一英寸的点处产生磁场强度的一个很大变化。在这样构造的一台机器中，这种被称为“漏磁”的影响相对较小，并且也只有轻微的电枢反作用。

Either the armature-conductor or the field-magnet may be stationary while the other rotates, and as it is often desirable to maintain the conductors stationary and to rotate the field-magnet I have made a special modification of the construction of the machine for this purpose, and with a view in such case

of still further simplifying the machine and rendering it more easy to maintain in operation I arrange the armature-conductors and the frame or supports therefor so as to support also a fixed coil or coils for energizing the rotating field-magnet, thus obviating the employment of all sliding contacts.

电枢导体或场磁体中的任一个可以是静止的，而另一个旋转的，并且由于经常希望保持导体静止并旋转场磁体，我为此目的对机器的结构进行了特殊的改进，并且考虑到在这种情况下进一步简化机器并使其在运行中更容易维护，我布置了电枢导体和框架或支撑件，以便还支撑用于励磁旋转场磁体的一个或多个被固定的线圈，从而避免使用所有的滑动触点。

In the accompanying drawings I have illustrated the two typical forms of my machine above referred to.

在附图中，我已经说明了上述我的机器的两种典型形式。

Figure 1 is a vertical central section of the machine, taken on lines x x of Fig. 2; and Fig. 2 is horizontal section on line y y of Fig. 1. The machine in these two figures is one in which the armature-conductor and the field-coil are stationary while the field-magnet core revolves. Fig. 3 is a vertical central section of a machine embodying the same plan of construction, but having a stationary field-magnet and rotating armature. Fig. 4 is a diagram illustrating the peculiar configuration of the polar faces and the relation of the armature conductor or conductors thereto.

图 1 是沿图 2 中的 xx 线截取的机器的垂直中心截面图；图 2 是图 1 中 yy 线的水平截面图。在这两幅图中的电动机是同一个，其电枢导体和励磁线圈是静止的，而场磁体铁芯是旋转的。图 3 是体现相同结构方案的机器的垂直中心截面图，但具有一个静止场磁体和旋转电枢。图 4 是展示出极面的特殊构造以及电枢导体与极面的关系的示意图。

In Figs. 1 and 2, A A designate two cylindrical castings provided with bracket-arms B B, in which latter are bushings C for the rotating shaft. The conductor in which the currents are induced may be constructed or arranged in various ways; but I prefer to form it in the following manner: I take an annular plate of copper D and by means of a saw or other cutting-tool cut in it radial slots from one edge nearly through to the other, beginning alternately from opposite edges. In this way a continuous zigzag conductor is formed. To the inner edge of this plate are secured two rings of non-magnetic metal E, which are insulated from the copper conductor, but held firmly thereto, as by means of bolts F. Within the rings E is then placed an annular coils G, which is the energizing-coil for the field-magnet. The conductor D and the parts attached thereto are supported by means of the cylindrical shell or casting A A, the two parts of which are brought together and clamped by bolts F' to the outer edge of the conductor D. The conductor D is also insulated from the shell A.

在图 1 和 2 中，A A 表示配有支架臂 B B 的两个圆筒形铸件，在支架臂 B B 中有用于旋转轴的衬套 C。在其中被感应来产生电流的导体可以以各种方式构建或布置；但是我更喜欢以下面的方式形成它：我拿一个环形的铜板 D，通过锯或其他切割工具在它上面切割辐射状的槽，从一个边缘几乎穿过另一个边缘，交替地从相对的边缘开始反向切割。这样就形成了连续的之字形导体（类似盘绕的线圈匝圈）。该板的内边缘固定有两个非磁性金属环 E，它们与铜导体绝缘，但通过螺栓 F 牢固地固定该板上。在环 E 内放置一个环形线圈 G，它是场磁铁的励磁线圈。导体 D 和连接到导体 D 上的部件由圆筒形外壳或铸件 A A 支撑，外壳或铸件

的两个部件靠在一起，并用螺栓 F' 夹紧到导体 D 的外边缘。导体 D 也与外壳 A 绝缘。

The core for the field-magnet is built up of two circular parts H H, formed with annular grooves I, which, when the two parts are brought together, form a space for the reception of the energizing-coil G. The central parts or hubs of the cores H H are trued off, so as to fit closely against one another, while the outer portions or flanges which form the polar faces J J are reduced somewhat in thickness to make room for the conductor D, and are serrated on their faces or provided in any other convenient way with polar projections. The two parts of the core H H are mounted on and fixed to the shaft K, and are bound together by bolts L. The number of serrations in the polar faces is arbitrary; but there must exist between them and the radial portions of the conductor D a certain relation, which will be understood by reference to Fig. 4, in which N N represent the projections or points on one face of the core of the field, and S S the points of the other face. The conductor D is shown in this figure in section, a a' designating the radial portions of the conductor, and b the insulating-divisions between the same. The relative width of the parts a a' and the space between any two adjacent points N N or S S is such that when the radial portions a of the conductor are passing between the opposite points N S, where the field is strongest, the intermediate radial portions a' are passing through the widest spaces midway between such points and where the field is weakest. Since the core on one side is of opposite polarity to the part facing it, all the points or projections of one polar face will be of opposite polarity to those of the other face. Hence, although the space between any two adjacent points on the same face may be extremely small, there will be no leakage of the magnetic lines between any two points of the same name; but the lines of force will pass across from one set of points to the other. The construction followed obviates to a great degree the distortion of the magnetic lines by the action of the current in the conductor D, in which it will be observed the current is flowing at any given time from the center toward the periphery in one set of radial parts a and in the opposite direction in the adjacent parts a'.

用于场磁体的铁芯由两个圆形部件 HH 构成，这两个部件形成有环形凹槽 I，当这两个部件合在一起时，形成用于容纳励磁线圈 G 的空间。铁芯 HH 的中心部件或毂被修整，以便彼此紧密贴合，而形成极面 JJ 的外部部分或凸缘在厚度上稍微减小，以便为导体 D 留出空间，并且在它们的表面上呈锯齿状或以任何其它方便的方式设置有极突起。铁芯 HH 的两个部件安装并固定在轴 K 上，并用螺栓 L 连接在一起。极面中锯齿的数量是任意的；但是在它们和导体 D 的辐射状部分之间必须存在某种关系，这将通过参考图 4 来理解，在图 4 中，NN 表示磁场的铁芯的一个面上的突起或点，SS 表示另一个面上的点。导体 D 在该图中以截面图展示，a a' 表示导体的辐射状部分，b 表示 a a' 之间的绝缘部分。部件 a a' 和任意两个相邻点 NN 或 SS 之间的空间的相对宽度是这样的，即当导体的辐射状部分 a 正在穿过磁场最强的相对点 NS 之间时，中间辐射状部分 a' 正在穿过这些点中间最宽的空间，这里的磁场最弱。因为一侧的铁芯与面对它的部件极性相反，所以一个极面的所有点或突起与另一个极面的那些点或突起极性相反。因此，尽管同一面上任意两个相邻点之间的空间可能极小，但是在任意两个同名点之间不会有磁力线泄漏；但是磁力线会从一组点横穿到另一组点。所采用的结构在很大程度上避免了由于导体 D 中电流的作用而导致的磁力线扭曲，在导体 D 中，可以观察到，在任何给定的时间，电流在一组辐射状部件 a 中从中心向外围流动，而在相邻的部分 a' 中以相反的方向流动。

In order to connect the energizing-coil G with a source of continuous current, I have found it convenient to utilize two adjacent radial portions of the conductor D for connecting the terminals of the coil G with two binding-posts M. For this purpose the plate D is cut entirely through, as shown,

and the break thus made is bridged over by a short conductor c.

为了将励磁线圈 G 与一个恒向电流源连接，我发现利用导体 D 的两个相邻的辐射状部分将线圈 G 的终端与两个接线柱 M 连接起来是很方便的。为此，如图所示，板 D 被完全切开，这样形成的裂口由一个短导体 c 桥接。

At any convenient point the plate D is cut through to form two terminals d, which are connected to binding-posts N.

在任何方便的点，板 D 被贯穿切开以形成两个终端 d，这两个终端连接到接线柱 N。

The core H H, when rotated by the driving-pulley P, generates in the conductors D an alternating current, which is taken off from the binding-posts N. It will be observed that from the nature of the construction described this machine is capable of producing an alternating current of an enormously high rate of alternations.

当铁芯 H H 被驱动滑轮 P 转动时，铁芯 H H 在导体 D 中产生交流电，该交流电从接线柱 N 取出。从所述结构的性质可以看出，该机器能够产生具有极高交替速率的交流电。

When it is desired to rotate the conductor between the faces of a stationary field-magnet, I adopt the construction shown in Fig. 3. The conductor D in this case is or may be made in substantially the same manner as above described by slotting an annular conducting-plate and supporting it between two heads O, held together by bolts o and fixed to the driving-shaft K. The inner edge of the plate or conductor D is preferably flanged to secure a firmer union between it and the heads O. It is insulated from said head. The field-magnet in this case consists of two annular parts H H, provided with annular grooves I for the reception of the coils. The flanges or faces surrounding the annular groove are brought together, while the inner flanges are serrated, as in the previous case, and form the polar faces. The two parts H H are formed with a base R, upon, which the machine rests.

当需要在一个静态场磁体的不同面之间旋转导体时，我采用图 3 所示的结构。在这种情况下，导体 D 是或者可以用与上述基本相同的方式制成，通过开槽一个环形导电板并将其支撑在两个头部 O 之间，通过螺栓 o 夹在一起并固定到驱动轴 K 上。板或导体 D 的内边缘优选带有凸缘，以确保它和头部 O 之间更牢固的结合。它与所述头部绝缘。在这种情况下，场磁体由两个环形部分 H H 组成，配有用于容纳线圈的环形凹槽 I。围绕环形槽的凸缘或面被集合在一起，而内凸缘是锯齿状的，如前一种情况，并形成了极面。这两个部件 H H 由一个基座 R 形成，机器放置在基座 R 上。

S S are non-magnetic bushings secured or set in the central opening of the cores.

S S 是固定或设置在铁芯中心开口的非磁性套管。

The conductor D is cut entirely through at one point to form terminals, from which insulated conductors T are led through the shaft to collecting-rings V.

导体 D 在某一点处被完全贯穿切开以形成终端，绝缘导体 T 从该端子通过轴被引导至集电

环 V。

What I claim is—

我主张的是—

1. The combination, in an annular field of force formed by opposing polar faces with radial grooves or serrations and with said poles, of a connected series of radial conductors so disposed with relation to the serrations that while one portion of the radial conductors is passing between the strongest parts of the field, or the points where the two poles most nearly approach, the adjacent or intermediate conductors will pass through the weakest parts of the field, or the points where the two poles are most remote, as set forth.

1、在由具有辐射状凹槽或锯齿的相对极面和所述极形成的一个环形力场中，存在着一系列相连的辐射状导体的组合，这些导体相对于锯齿如此设置，使得当辐射状导体的一部分通过磁场最强部分之间或两极最接近的点之间时，相邻的或中间的导体将穿过磁场最弱的部分，或两极最远离的点之间，如上所述。

2. The combination, with a connected series of radial conductors forming an annular coil, of a stationary two-part supporting-frame clamped to and insulated from the outer ends of said conductors, a ring formed in two parts clamped to the inner ends of the same, an energizing-coil contained in said ring, and field-core made in two parts and enclosing said energizing-coil and presenting annular polar faces to the series of radial conductors, as described.

2、存在着一个组合，它包括：连接的一系列辐射状导体，它们形成一个环形线圈；一个静态双部件支撑框架被夹紧到所述导体的外端并与该外端绝缘；在两个部件中组成的一个环被加紧到导体的内端；被包含在所述环中的一个励磁线圈；以及由两部分制成的励磁铁芯，该励磁铁芯包围所述励磁线圈，并向一系列辐射状导体呈现环形极面，如上所述。

3. The combination, with the annular conducting-plate slotted to form a connected series of radial conductors, a sectional supporting-frame secured to and insulated from the outer edge of the slotted plate, a sectional ring secured to and insulated from the inner edge of said plate, a hollow energizing-coil contained in said ring, and a field-core composed of two parts bolted together and recessed to enclose the energizing-coil, said cores being mounted in a rotating shaft, as set forth.

3. 存在着一个组合，它包括：环形导电板被开槽以形成一系列相连的辐射状导体；固定到开槽板的外边缘并与其绝缘的一个分段的支撑框架；固定到所述板的内边缘并与其绝缘的一个分段的环；被包含在所述环中的一个中空励磁线圈；以及由螺栓连接在一起的两个部件构成的一个励磁铁芯，这两个部件具有壁凹，以容纳并包围励磁线圈；所述铁芯被安装在一个旋转轴上，如上所述。

4. The combination, with two annular polar faces of opposite magnetic polarity and formed with opposite points, projections, or serrations, of a conductor turned back upon itself in substantially radial convolutions and mounted in the annular field, whereby a rotation of the field or said conductor will develop therein an alternating current, as set forth.

4、存在着一个组合，它包括：相反磁极性的两个环形极面和形成的相对的点、突起或锯齿；一个导体基本上以辐射状盘绕的方式自身回转并被安装在环形磁场内，由此磁场或所述导体的旋转将在其中产生交流电，如上所述。

5. The combination, with a polar face of given polarity formed with grooves or serrations, of a polar face of opposite polarity with corresponding grooves or serrations, the two polar faces being placed with their grooves opposite to each other, and a conductor or coil mounted between said faces with the capability of movement across the lines of force in a direction at right angles to that of the grooves or serrations, as set forth.

5、存在着一个组合，它包括：一个给定极性的极面，它形成有凹槽或锯齿；一个带有相反极性的极面，它形成有相应的凹槽或锯齿；两个极面被放置成它们的凹槽彼此相对；并且一个导体或线圈被安装在所述极面之间，该导体或线圈具有在与凹槽或锯齿方向成直角的方向上穿过力线进行移动的能力，如上所述。

6. In a magneto-electric machine, the combination of a sectional frame, a field-magnet core composed of two connected parts, a rotating shaft on which said core is mounted, a conductor in which currents are to be induced, the convolutions of which are radially disposed between the polar faces of the field-core and secured to and supported by the frame, and an energizing-coil for the field-core supported by the induced-current coil and contained in an annular recess formed by grooves in the faces of the two sections of the field-core.

6、存在着一个组合，它包括：一个组合框架；一个由两个连接部件组成的场铁芯；一个安装有所述铁芯的旋转轴；一个能在自身中感应出电流的导体，该导体的盘绕以辐射状排列的方式布置在场铁芯的极面之间，并固定在框架上并由框架支撑；一个用于场铁芯的励磁线圈由感应电流线圈供电，并被容纳在由场铁芯的两个部分的表面上的壁凹所形成的环形凹槽中。

7. The combination, with opposing field-magnet poles formed with projections or serrations in their faces, the highest parts or prominences of one face being opposite to those of the other, of a conductor the convolutions of which are adapted to pass at right angles through the magnetic lines between the opposing prominences, as set forth.

7、存在着一个组合，它包括：相对的场磁极，在其表面上形成有突起或锯齿；一个表面的最高部分或突起，它们与另一个表面的最高部分或突起相对；一个自身的盘绕适用以直角方向穿过相对突起之间的磁力线的导体，如上所述。

8. The combination, with a rotating field-magnet core having two opposing and annular polar faces with radial grooves or serrations therein systematically disposed, so that the highest parts or prominences of one face lie opposite to those of the other, of a stationary conductor with radial convolutions and mounted between the polar faces, as set forth.

8、存在着一个组合，它包括：一个旋转场铁芯，它具有两个相对的环形极面，这两个极面，有组织地设置有辐射状排列的凹槽或锯齿，使得一个面的最高部分或突起与另一个面的最高部分或突起相对；一个静态导体具有辐射状盘旋并安装在所述极面之间，如上所述。

NIKOLA TESLA.

尼古拉·特斯拉

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PARKER N. PAGE.

见证人:

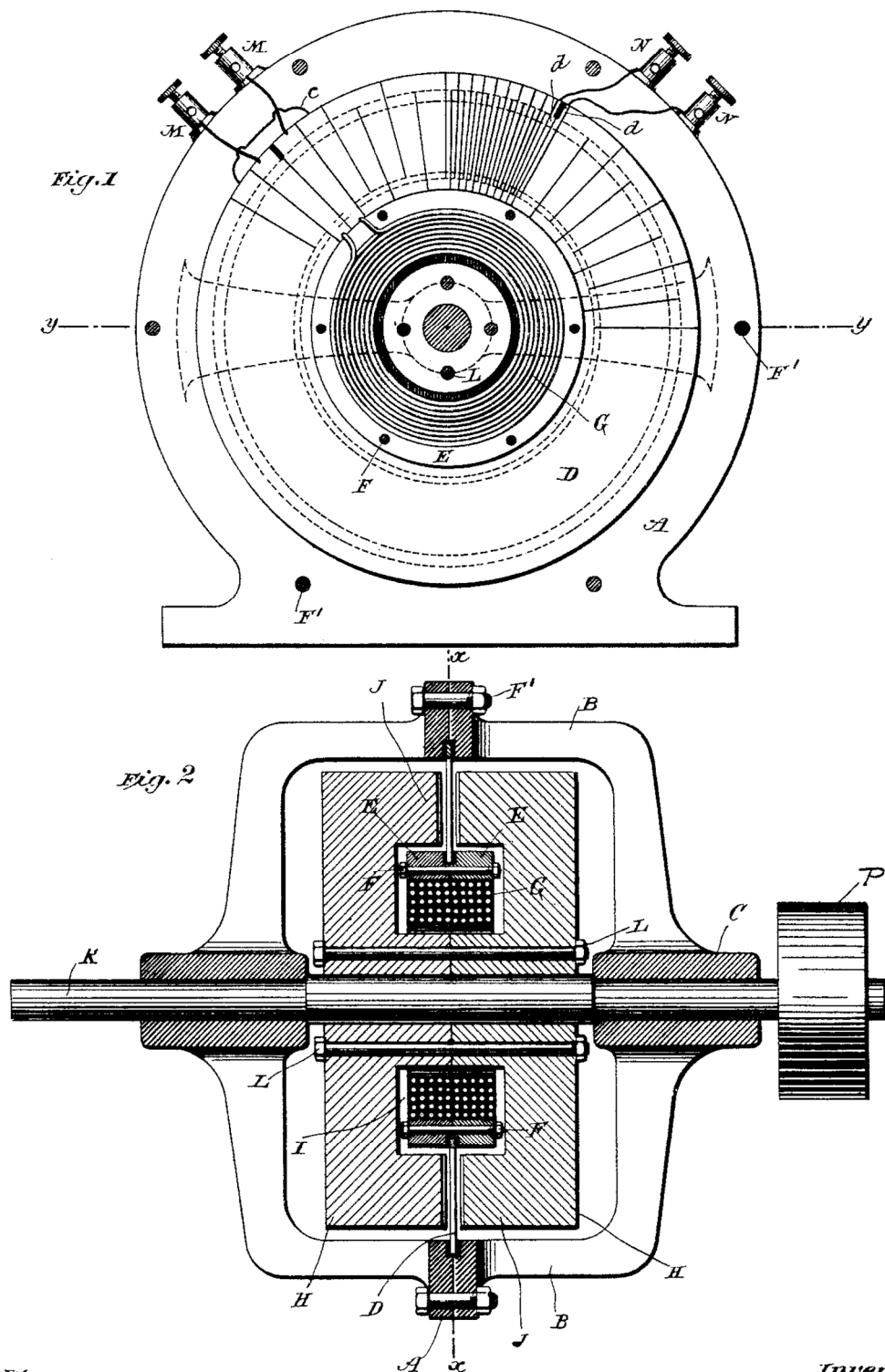
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N. TESLA.

ALTERNATING ELECTRIC CURRENT GENERATOR.

No. 447,921.

Patented Mar. 10, 1891.



Witnesses:
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Frank B. Murphy.

Inventor
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ALTERNATING ELECTRIC CURRENT GENERATOR.

No. 447,921.

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Fig. 3

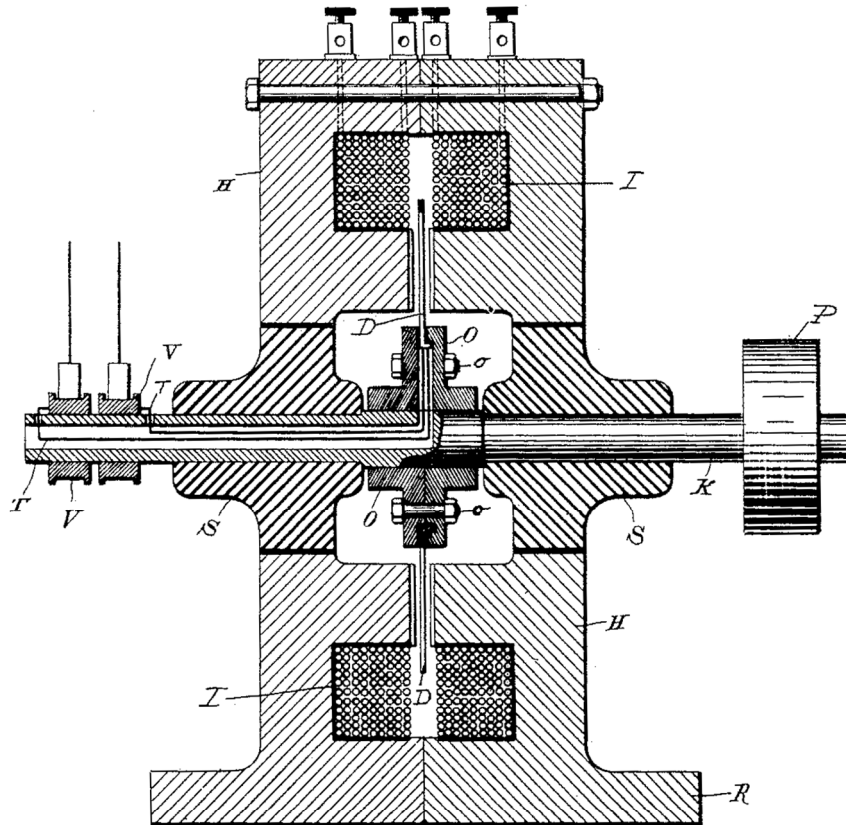
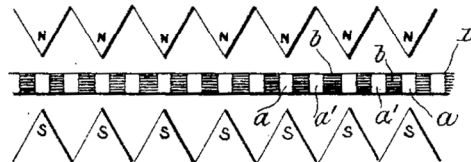


Fig. 4



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ELECTRO-MAGNETIC MOTOR.

电磁电动机

NIKOLA TESLA, OF NEW YORK, N. Y.

纽约州纽约市的尼古拉·特斯拉

SPECIFICATION forming part of Letters Patent No. 455,067, dated June 30, 1891.

Application filed January 27, 1891. Serial No. 379,251. (No model.)

该说明书形成了颁发于 1891 年 6 月 30 日编号为 455,067 的专利证书的一部分。

申请于 1891 年 1 月 27 日提交。序列号为 379,251。(没有模型)

To all whom it may concern:

致所有相关人士:

Be it known that I, NIKOLA TESLA, a subject of the Emperor of Austria, from Smiljan, Lika, border country of Austria-Hungary, residing at New York, in the county and State of New York, have invented certain new and useful Improvements in Electro-Magnetic Motors, of which the following is a specification, reference being had to the accompanying drawings.

众所周知，我、尼古拉·特斯拉、一位奥匈帝国的臣民，来自奥匈帝国边境地区的利卡县的史密里安村，现在居住在纽约州纽约郡纽约市，在电磁电动机方面已经发明了某些新的和有用的改进，以下是该发明一个说明书，必须参考随附的图纸。

The subject of my present invention is an improvement primarily designed for application to alternating-current motors of the special type invented by me, and of which the operation is due to the action of alternating currents differing in phase and directed through or developed in independent energizing-circuits in the motor, and causing a shifting or rotation of the magnetic poles or their resultant attractive forces upon the rotating element or armature.

我的本发明的主题是一种改进，主要设计用于我发明的特殊类型的交流电动机的应用，并且其运行是由于不同相位的交流电流的作用，并且该交流电被引导流过电动机中的独立励磁电路或者在上述电路中发展产生，并且引起磁极的转移或旋转或者它们的施加在旋转组件或者电枢上的合成吸引力。

My improvements are based upon certain laws governing the action or effects produced by a condenser when connected to an electric circuit through which an alternating or in general an undulating current is made to pass. Some of these effects, and those most important in connection with my invention, are as follows: First, if the terminals or plates of a condenser be connected with two points of a circuit, the potentials of which are made to rise and fall in rapid succession, the condenser allows the passage or, more strictly speaking, the transference of a current, although its plates or armatures may be so carefully insulated as to prevent almost completely the passage of a current of unvarying strength or direction and of moderate electro-motive force; second, if a circuit the terminals of which are connected with the

plates of the condenser possess a certain self-induction, the condenser will overcome or counteract to a greater or less degree, dependent upon well-understood conditions, the effect of such self-induction; third, if two points of a closed or complete circuit through which a rapidly raising and falling current flows be shunted or bridged by a condenser, a variation in the strength of the currents in the branches and also a difference of phase of the currents therein is produced. These effects I have utilized and applied in a variety of ways in the construction and operation of my motors, as by producing a difference in phase in the two energizing-circuits of an alternating-current motor by connecting the two circuits in derivation and connecting up a condenser in series in one of the circuits; but such applications seem to be obvious to one familiar with my motors and the facts above enumerated.

我的改进是基于某种规律，当电容器连接到交流电流或通常的波动电流流过的一个电路时，该规律支配着由电容器产生的动作或效应。这些效应中的一些，以及与我的发明有关的那些最重要的效应如下：首先，如果一个电容器的终端或极板与一个电路的两点相连，会导致该两点电位的快速相继的上升和下降，电容器允许电流通过，或者更严格地说，允许电流的转移，尽管其极板或电枢会被非常仔细地绝缘，几乎完全防止恒定强度或恒定方向和中等电动势的电流通过；其次，如果一个其终端与电容器的极板连接的电路具有一定的自感，该电容器将或多或少克服或抵消这种自感的影响，克服的程度取决于很好理解的条件；最后，如果一个快速上升和下降的电流所流过的一个闭合的或完整的电路的两点被电容器分流或桥接，则在支路中电流强度的变化以及电流的相位差也都会产生。这些影响到我已经使用和应用的构建和运行我的电动机的各种方式，例如通过间接连接（通过一个线圈进行连接）两个电路并在其中一个电路中串联连接一个电容器，以在一个交流电动机的两个励磁电路中产生一个相位差；但是对于熟悉我的电动机和上面列举的事实的人来说，这样的应用似乎是显而易见的。

My present improvement, however, possesses certain novel features of practical value and involve a knowledge of facts less generally known. These improvements comprise the use of a condenser or condensers in connection with the induced or armature circuit of a motor and certain details of the construction of such motors. In an alternating-current motor of the type to which I have particularly referred above, or in any other which has an armature coil or circuit closed upon itself, the latter represents not only an inductive resistance, but one which is periodically varying in value, both of which facts complicate and render difficult the attainment of the conditions best suited to the most efficient working of the motors. The most efficient working conditions, in other words, require, first, that for a given inductive effect upon the armature there should be the greatest possible current through the armature or induced coils, and, second, that there should always exist between the currents in the energizing and the induced circuit a given relation of phase. Hence whatever tends to decrease the self-induction and increase the current in the induced circuits will, other things being equal, increase the output and efficiency of the motor, and the same will be true of causes that operate to maintain the mutual attractive effect between the field-magnets and armature at its maximum. I secure these results by connecting with the induced circuit or circuits a condenser, in the manner hereinafter described, and I also, with this purpose in view, construct the motor in a special manner.

然而，我的本改进拥有某些具有实用价值的新颖特征，并且涉及对鲜为人知的事实的了解。这些改进包括使用一个或多个与电动机的感应电路或电枢电路相连的电容器，以及这种电动机结构的某些细节。在我上面特别提到的类型的交流电动机中，或者在任何其他具有在电枢上自身闭合的一个线圈或电路的一个交流电动机中，该线圈或电路不仅代表一个感抗，而且

代表了值的周期性变化,这两个事实都使获得最适合电动机的最有效工作的条件变得复杂和困难。换句话说,最有效的工作条件要求,首先,对于施加在电枢上的一个给定的感应效应,应该有最大可能的电流通过电枢或感应线圈,其次,在励磁电路和感应电路中的电流之间应该总是存在给定的相位关系。因此,无论倾向于减少自感和增加感应电路中的电流,在其他条件相同的情况下,都会增加电动机的输出和效率,同样的道理也适用于将场磁体和电枢之间的相互吸引效应保持在其最大值的原因。通过将一个电容器连接到一个感应电路或多个感应电路上,我确保了这些结果,以下面描述的方式,我也考虑到这个目的,就是以一种特殊的方式构建电动机。

Referring to the drawings for a particular description of the invention, Figure 1 is a view, mainly diagrammatic, of an alternating-current motor to which my present invention is applied. Fig. 2 is a central section, in line with the shaft, of a special form of armature-core adapted to the invention. Fig. 3 is a similar section of a modification of the same. Fig. 4 is one of the sections of the core detached. Fig. 5 is a diagram showing a modified disposition of armature or induced circuits.

参照附图对本发明进行具体描述,图1是应用本发明的交流电动机的主要示意图。图2是适用于本发明的特殊形式的电枢铁芯的与轴成一条直线的中心截面图。图3是上述电枢铁芯的修改后的类似截面图。图4是分离出的铁芯的其中一部分。图5是展示电枢电路或感应电路的一个修改后的布置的示意图。

The general plan of the invention is illustrated in Fig. 1. A A in this figure represent the frame and field-magnets of an alternating-current motor, the poles or projections of which are wound with coils B and C, forming independent energizing-circuits connected either to the same or to independent sources of alternating currents, as is now well understood, so that the currents flowing through the circuits, respectively, will have a difference of phase. Within the influence of this field is an armature-core D, wound with coils E. In my motors of this description heretofore these coils have been closed upon themselves, or connected in a closed series; but in the present case each coil or the connected series of coils terminates in the opposite plates of a condenser F. For this purpose the ends of the series of coils are brought out through the shaft to collecting-rings G, which are connected to the condenser by contact-brushes H and suitable conductors, the condenser being independent of the machine. The armature-coils are wound or connected in such manner that adjacent coils produce opposite poles.

本发明的总体方案如图1所示。该图中的A A代表一个交流电动机的框架和场磁体,其磁极或突出部分缠绕有线圈B和C,形成连接到同一个或独立的交流电源的独立励磁电路,这是现在很好理解的,使得流过电路的电流分别具有一个不同的相位。在这个磁场的影响范围内是一个电枢铁芯D,其上缠绕着线圈E。在我的这种描述的电动机中,迄今为止,这些线圈已经自身闭合,或者连接成一组闭合的串联;但是在这种情况下,每个线圈或每个被串联连接的线圈系列都终止于一个电容器F的相对极板。为此,被串联连接的线圈系列的终端通过轴引出到集电环G,集电环G通过接触刷H和合适的导体连接到电容器,电容器独立于机器。电枢线圈的缠绕或连接方式使得相邻线圈产生相反的磁极。

The action of this motor and the effect of the plan followed in its construction are as follows: The motor being started in operation and the coils of the field-magnets being traversed by alternating currents, currents are induced in the armature-coils by one set of field-coils, as B, and the poles thus established are acted upon by the other set, as C. The armature-coils, however, have necessarily a high

self-induction which opposes the flow of the currents thus set up. The condenser F not only permits the passage or transference of these currents, but also counteracts the effects of self-induction, and by a proper adjustment of the capacity of the condenser, the self-induction of the coils, and the periods of the currents the condenser may be made to overcome entirely the effect of the self-induction.

该电动机的动作和在其构造中遵循的方案的效果如下：正在启动的电动机处在运行中，在磁场体线圈中流过交流电流，一组励磁线圈（如 B）在电枢线圈中感应出电流并建立了磁极，另一组励磁线圈（如 C）作用于因此建立的磁极。然而，电枢线圈必然具有一个高的自感，该自感抵抗由此产生的电流。该电容器 F 不仅允许这些电流的通过或转移，而且抵消自感的影响，并且通过适当调整电容器的容量、线圈的自感和电流的周期，可以使电容器完全克服自感的影响。

It is preferable on account of the undesirability of using sliding contacts of all kinds to associate the condenser with the armature directly, or make it a part of the armature. In some cases I build up the armature of annular plates K K, held by bolts L between heads M, which are secured to the driving-shaft, and in the hollow space thus formed I place a condenser F, generally by winding the two insulated plates thereof spirally around the shaft. In other cases I utilize the plates of the core itself as the plates of the condenser. For example, in Figs. 3 and 4, N is the driving-shaft, M M are the heads of the armature-core, and K K' the iron plates of which the core is built up. These plates are insulated from the shaft and from one another, and are held together by rods or bolts L. The bolts pass through a large hole in one plate and a small hole in the one next adjacent, and so on, connecting electrically all of plates K, as one armature of the condenser, and all of plates K' as the other.

最好是考虑到用各种滑动触点来将电容器与电枢直接关联，或者使其成为电枢的一部分是不受欢迎的。在一些情况下，我制造环形板电枢 K K，由头部 M 之间的螺栓 L 夹住，头部 M 被固定到传动轴，并且在因此形成的中空空间中，我通常通过将两个被绝缘板螺旋缠绕在传动轴上的方式放置一个电容器。在其他情况下，我利用铁芯本身的板作为电容器的极板。例如，在图 3 和图 4 中，N 是传动轴，MM 是电枢铁芯的头部，K K' 是构成铁芯的铁板。这些板与轴绝缘，彼此绝缘，并用杆或螺栓 L 夹在一起。螺栓穿过一个极板上的大孔和下一个相邻极板上的小孔，以此类推，将作为电容器电容板的所有极板 K 和作为另一块电容板的所有极板 K' 进行电连接。

To either of the condensers above described the armature-coils may be connected, as explained by reference to Fig. 1.

如参考图 1 所解释的，电枢线圈可以连接到上述电容器中的任一个。

In motors in which the armature-coils are closed upon themselves—as, for example, in any form of alternating-current motor in which one armature coil or set of coils is in the position of maximum induction with respect to the field coils or poles, while the other is in the position of minimum induction—the coils are preferably connected in one series, and two points of the circuit thus formed are bridged by a condenser. This is illustrated in Fig. 5, in which E represents one set of armature-coils and E' the other. Their points of union are joined through a condenser F. It will be observed that in this disposition the self-induction of the two branches E and E' varies with their position relatively to the field-magnet, and that each branch is alternately the predominating source of the induced current.

Hence the effect of the condenser F is twofold. First, it increases the current in each of the branches alternately, and, secondly, it alters the phase of the currents in the branches, this being the well-known effect which results from such a disposition of a condenser with a circuit, as above described. This effect is favorable to the proper working of the motor, because it increases the flow of current in the armature-circuits due to a given inductive effect, and also because it brings more nearly into coincidence the maximum magnetic effects of the coacting field and armature-poles.

在电枢线圈自身闭合的电动机中——例如，在任何形式的交流电动机中，一个电枢线圈或一组线圈相对于励磁线圈或磁极处于最大感应位置，而另一个电枢线圈或另一组线圈处于最小感应位置——线圈最好串联连接，电路的两点因此被一个电容器桥接。这在图 5 中被展示出，图中的 E 代表一组电枢线圈，E'代表另一组。它们的结合点通过一个电容器 F 连接起来。将会观察到，在这种布置中，两个分支 E 和 E'的自感随着它们相对于场磁体的位置而变化，并且每个分支交替地是感应电流的主要来源。因此，电容器 F 的作用是双重的。首先，它交替地增加每个分支中的电流，其次，它改变分支中电流的相位，这是众所周知的效果，是由如上所述的具有一个电路的一个电容器的这样一种布置所产生。这种效应有利于电动机的正常工作，因为由于一个给定的感应效应，它增加了电枢电路中的电流，还因为它使共同作用中的磁场的和电枢磁极的最大磁效应更加接近实时重合。

It will be understood, of course, that the causes that contribute to the efficiency of condensers when applied to such uses as above must be given due consideration in determining the practicability and efficiency of the motors. Chief among these is, as is well known, the periodicity of the current, and hence the improvements which I have herein described are more particularly adapted to systems in which a very high rate of alternation or change is maintained.

当然，应该理解的是，当电容器应用于上述用途时，在确定电动机的实用性和效率方面，必须适当考虑影响电容器效率的原因。众所周知，其中最主要的是电流的周期性，因此我在这里描述的改进更特别适合于系统中保持非常高的交替或变化率。

Although this invention has been illustrated herein in connection with a special form of motor, it will be understood that it is equally applicable to any other alternating-current motor in which there is a closed armature-coil wherein the currents are induced by the action of the field, and, furthermore, I would state that the feature of utilizing the plates or sections of a magnetic core for forming the condenser, I regard as applicable, generally, to other kinds of alternating-current apparatus.

虽然本发明在这里是结合一种特殊形式的电动机来说明的，但是应当理解，它同样适用于任何其他交流电动机，在这类电动机中要有一个闭合的电枢线圈，在该电枢线圈中，电流是由磁场作用感应产生的，此外，我要说明的是，利用磁芯的板或部件来形成电容器的这一特征，我认为总的来说该特征也适用于其它种类的交流设备。

Having now described my invention, what I claim is—

现在描述了我的发明，我主张的是—

1. In an alternating-current motor, the combination, with the field-magnets and energizing-circuit, of an armature-circuit and a core adapted to be energized by currents induced in its circuit by the currents

in the field-circuit, and a condenser connected with the armature-circuit only, as set forth.

1、在一个交流电动机中，存在一个组合，它包括：励磁磁体和励磁电路；一个电枢电路和一个铁芯，该电枢电路和铁芯适于由在励磁电路中的电流在电枢电路中感应出的电流来激励；以及仅与电枢电路连接的一个电容器，如上所述。

2. In an alternating-current motor, the combination, with armature-coils in inductive relation to the field and connected in a closed circuit, of a condenser bridging said circuit, as set forth.

2、在一个交流电动机中，存在一个组合，它包括：与磁场有感应关系的电枢线圈，它们被连接在一个闭合电路中；一个与所述电路桥接的电容器，如上所述。

3. In an alternating-current motor, the combination, with an armature and two energizing-circuits formed by coils wound thereon in different inductive relations to the field and joined in a continuous or closed series, of a condenser the plates of which are connected, respectively, to the junctions of the circuits or coils, as set forth.

3、在一个交流电动机中，存在一个组合，它包括：一个电枢和两个励磁电路的组合，这两个励磁电路是由线圈绕在电枢上形成的，线圈与磁场有不同的感应关系，并以一个连续的或闭合的串联连接；一个电容器，其极板分别连接到电路或线圈的连接点，如上所述。

4. In an alternating-current motor, the combination, with the induced energizing-coil or coils of the armature, of a condenser connected therewith and made a part of the armature or rotating element of the motor.

4、在一个交流电动机中，存在一个组合，它包括：被感应的励磁线圈或电枢线圈；一个电容器与所述线圈连接并成为电枢的一部分或电动机的旋转组件。

5. In an alternating-current motor, the combination, with an armature-core composed of insulated conducting-plates alternately connected to form a condenser, of an induced energizing coil or coils wound thereon and connected to the plates or armatures of the said condenser.

5、在一个交流电动机中，存在一个组合，它包括：一个电枢铁芯，它由被绝缘的导电板组成，上述导电板被交替连接以形成一个电容器；一个被感应的励磁线圈或缠绕在电枢铁芯上线圈，并连接到所述电容器的极板或电枢上。

6. A magnetic core for alternating-current apparatus, composed of plates or sections insulated from each other and alternately connected to form the two parts or armatures of a condenser.

6、用于交流电装置的一个磁芯，由相互绝缘的板或部件组成，并且它们被交替连接以形成一个电容器的两部分。

NIKOLA TESLA.

尼古拉·特斯拉

Witnesses:

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(No Model.)

N. TESLA.
ELECTRO MAGNETIC MOTOR.

No. 455,067.

Patented June 30, 1891.

Fig. 1

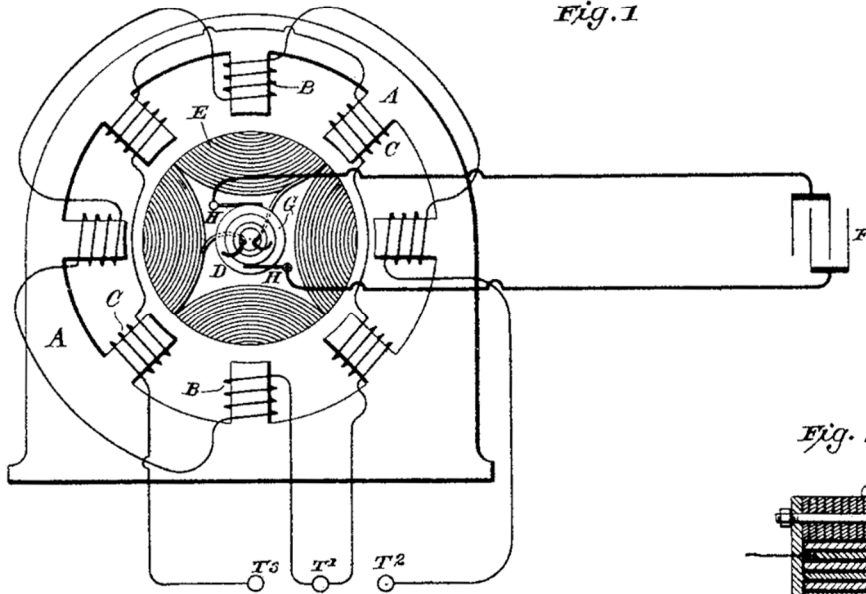


Fig. 2

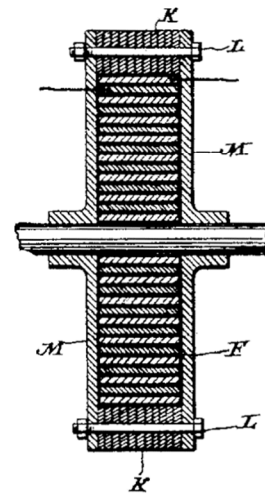


Fig. 3

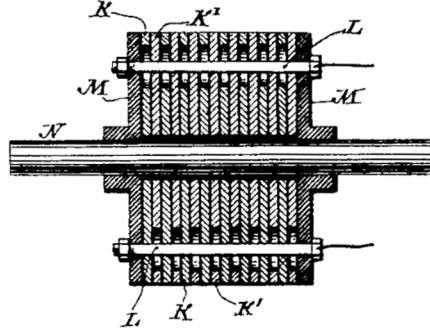


Fig. 4

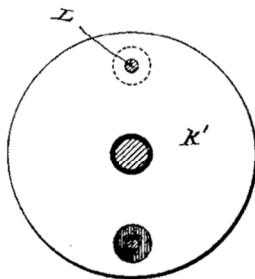
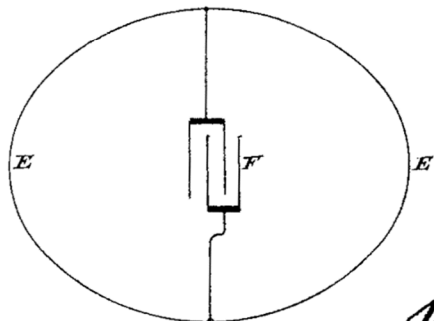


Fig. 5



Witnesses
Raphael Netter
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Nikola Tesla
by
Duncan & Page.
Attorneys.

ELECTRO-MAGNETIC MOTOR.

电磁电动机

NIKOLA TESLA, OF NEW YORK, N. Y., ASSIGNOR TO THE TESLA ELECTRIC
COMPANY, OF SAME PLACE.

纽约州纽约市的尼古拉·特斯拉将专利权转让给纽约市的特斯拉电气公司

SPECIFICATION forming part of Letters Patent No. 459,772, dated September 22, 1891.

Application filed April 6, 1889. Serial No. 306,165. (No model.)

该说明书形成了颁发于 1891 年 9 月 22 日编号为 459,772 的专利证书的一部分。

申请于 1889 年 4 月 6 日提交。序列号为 306,165。(没有模型)

To all whom it may concern:

致所有相关人士:

Be it known that I, NIKOLA TESLA, a subject of the Emperor of Austria, from Smiljan, Lika, border country of Austria-Hungary, residing at New York, in the county and State of New York, have invented certain new and useful Improvements in Electro-Magnetic Motors, of which the following is a specification, reference being had to the drawings accompanying and forming a part of the same.

众所周知，我、尼古拉·特斯拉、一位奥匈帝国的臣民，来自奥匈帝国边境地区的利卡县的史密里安村，现在居住在纽约州纽约郡纽约市，在电磁电动机方面已经发明了某种新的和有用的改进，以下是该发明一个说明书，必须参考随附的图纸，它已经形成了该说明的一部分。

As is well known, certain forms of alternating-current machines have the property, when connected in circuit with an alternating-current generator, of running as a motor in synchronism therewith; but while the alternating current will run the motor after it has attained a rate of speed synchronous with that of the generator it will not start it. Hence in all instances heretofore when these “synchronizing motors,” as they are termed, have been run, some means have been adopted to bring the motors up to synchronism with the generator, or approximately so, before the alternating current of the generator is applied to drive them.

众所周知，某些形式的交流电动机在与交流发电机相连时具有与交流发电机同步运行的特性；但是，当电动机达到与发电机同步的速度后，交流电流将使电动机运转，但不会启动电动机。因此，在迄今为止的所有情况下，当这些被称为“同步电动机”的电动机已经运行时，在发电机的交流电被施加来驱动电动机之前，已经采用了一些工具来使电动机与发电机同步，或者大致同步。

In an application filed February 18, 1889, Serial No. 300,220, I have shown and described an improved system of operating this class of motors, which consists, broadly, in winding or arranging the motor in such manner that by means of suitable switches it could be started as a multiple-circuit motor, or one operating by a progression of its magnetic poles, and then, when up to speed, or nearly so, converted

into an ordinary synchronizing motor, or one in which the magnetic poles were simply alternated.

在 1889 年 2 月 18 日提交的序列号为 300,220 的申请中, 我已经展示并描述了一种运行这类电动机的改进系统, 该系统主要包括以这样的方式缠绕或布置电动机, 即通过合适的开关, 它可以作为一个多电路电动机启动, 或者通过其磁极的前进来运行, 然后, 当达到速度或接近速度时, 转换成普通的一个同步电动机, 或者磁极简单交替的一个电动机。

In some cases, as when a large motor is used and when the number of alternations is very high, there is more or less difficulty in bringing the motor to speed as a double or multiple-circuit motor, for the plan of construction which renders the motor best adapted to run as synchronizing motor impairs its efficiency as a torque or double-circuit motor under the assumed conditions on the start. This will be readily understood, for in a large synchronizing motor the length of the magnetic circuit of the polar projections and their mass are so great that apparently considerable time is required for magnetization and demagnetization. Hence with a current of a very high number of alternations the motor may not respond properly. To avoid this objection and to start up a synchronizing motor in which these conditions obtain is the object of my present invention. I have therefore combined two motors, one a synchronizing motor, the other a multiple-circuit or torque motor, and by the latter I bring the first named up to speed, and then either throw the whole current into the synchronizing motor or operate jointly both of the motors.

在某些情况下, 当使用一个大型电动机且交替次数非常高时, 使电动机达到双电路或多电路电动机的速度或多或少会有些困难, 因为使电动机最适合运行的结构方案会损害它在启动时的假设条件下作为一个转矩电动机或一个双电路电动机的效率。这是很容易理解的, 因为在一个大型同步电动机中, 极性突起的磁路长度和质量都很大, 显然磁化和退磁需要相当长的时间。因此, 对于非常高交变数量的电流, 电动机可能不会正确响应。为了避免这一缺陷并启动一台同步电动机, 在该电动机中获得这些条件是我的本发明的目的。因此, 我将两个电机组合在一起, 一个是同步电动机, 另一个是多电路电动机或转矩电动机, 通过后者, 我使第一个提到的电动机达到速度, 然后要么将整个电流投入该同步电动机, 要么将这两个电动机连接起来运行。

This invention involves several novel and useful features. It will be observed, in the first place, that both motors are run without commutators of any kind, and, secondly, that the speed of the torque motor may be higher than that of the synchronizing motor, as will be the case when it contains a fewer number of poles or sets of poles, so that the motor will be more readily and easily brought up to speed. Thirdly, the synchronizing motor may be constructed so as to have a much more pronounced tendency to synchronism without lessening the facility with which it is started.

本发明包括几个新颖和有用的特征。将会看到, 首先, 两个电动机都在没有任何种类的换向器的情况下运行, 其次, 转矩电动机的速度可以高于同步电动机的速度, 当它包含较少数量的磁极或磁极组时将会是这种情况, 因此电动机将会更迅速和更容易地达到速度。最后, 同步电动机可以被构造成具有更明显的同步趋势, 而不减少其启动的便利性。

In the drawings I have illustrated the invention.

在附图中, 我已经说明了本发明。

Figure 1 is a part sectional view of the two motors; Fig. 2, an end view of the synchronizing motor; Fig. 3, an end view and part section of the torque or double-circuit motor; Fig. 4, a diagram of the circuit connections employed; and Figs. 5, 6, 7, 8 and 9 are diagrams of modified dispositions of the two motors.

图 1 是两个电动机的一个局部截面图；图 2 是同步电动机的一个端视图；图 3 是扭矩电动机或双电路电动机的端视图和部分截面图；图 4 是所采用的电路连接的示意图；图 5、图 6、图 7、图 8 和图 9 是这两种电动机的改进后的布置图。

Inasmuch as neither motor is doing any work while the current is acting upon the other, I prefer to rigidly connect the two armatures. I therefore mount both upon the same shaft A, the field-magnets B of the synchronizing and C of the torque motor being secured to the same base D. The preferably larger synchronizing motor has polar projections on its armature, which rotate in very close proximity to the poles of the field, and in other respects it conforms to the conditions, now well understood, that are necessary to secure synchronous action. I prefer, however, to wind the pole-pieces of the armature with closed coils E, as this obviates the employment of sliding contacts. The smaller or torque motor, on the other hand, has, preferably, a cylindrical armature F, without polar projections and wound with closed coils G, as I have described in my previous patents, notably No. 382,279, dated May 1, 1888. The field-coils of the torque motor are connected up in two series H and I, and the alternating current from the generator is directed through or divided between these two circuits in any manner to produce a progression of the poles or points of maximum magnetic effect. I secure this result in a convenient way by connecting the two motor-circuits in derivation with the circuit from the generator, inserting in one motor-circuit a dead resistance and in the other a self-induction coil, by which means a difference in phase between the two divisions of the current is secured. If both motors have the same number of field-poles, the torque motor for a given number of alternations will tend to run at double the speed of the other, for, assuming the connections to be such as to give the best results, its poles are divided into two series and the number of poles is virtually reduced one-half, which being acted upon by the same number of alternations tend to rotate the armature at twice the speed. By this means the main armature is more easily brought to or above the required speed. When the speed necessary for synchronism is imparted to the main motor, the current is shifted from the torque motor into the other.

因为当电流作用于另一个电动机时，这两个电动机都不做功，所以我更喜欢将两个电枢刚性连接。因此，我将两者安装在同一根轴 A 上，同步电动机的场磁体 B 和转矩电动机的场磁体 C 被固定在同一个底座 D 上。最好是较大的同步电动机在其电枢上具有极性突起，该极性突起在非常接近磁场磁极的位置旋转，并且在其他方面该电动机符合现在很好理解的确保同步动作所必需的条件。然而，我更喜欢用闭合线圈 E 缠绕电枢的极靴，因为这避免了滑动触点的使用。另一方面，较小的电动机或转矩电动机最好具有一个圆柱形电枢 F，没有极性突起并且缠绕有闭合线圈 G，正如我在以前的专利中所描述的，特别是在 1888 年 5 月 1 日授予的第 382,279 号专利。转矩电动机的励磁线圈被连接成两个串联 H 和 I，来自发电机的交流电以任何方式通过这两个电路或在这两个电路之间分流，以产生磁极或最大磁效应点的前进。我以一种方便的方式确保这个结果，通过间接连接这两个电动机电路与来自发电机的电路，在一个电动机电路中插入一个吸收电阻，在另一个电动机电路中插入一个自感线圈，这意味着电流的两个分流之间的相位差是有保证的。如果两个电动机具有相同数量的场磁极，对于给定数量的交流，转矩电动机将倾向于以另一个电动机的两倍速度运行，因为，假设连接能够提供最佳结果，电动机的磁极被分成两个串联，磁极的数量实际上减少了一半，

在相同数量的交流的作用下，倾向于以两倍的速度旋转电枢。通过这种方式，主电枢更容易达到或超过所需的速度。当同步所需的速度被赋予给主电动机时，电流从转矩电动机转移到另一个电动机中。

A convenient arrangement for carrying out this invention is shown in Fig. 4. In said figure J J are the field-coils of the synchronizing, and H I the field-coils of the torque motor. L L' are the conductors of the main line. One end of, say, coils H is connected to wire L, through a self-induction coil M. One end of the other set of coils I is connected to the same wire through a dead resistance N. The opposite ends of these two circuits are connected to the contact m of a switch the handle or lever of which is in connection with the line-wire L'. One end of the field-circuit of the synchronizing motor is connected to the wire L. The other terminates in the switch-contact n. From the diagram it will be readily seen that if the lever P be turned onto contact m the torque motor will start by reason of the difference of phase between the currents in its two energizing-circuits. Then when the desired speed is attained if the lever P be shifted onto contact n the entire current will pass through the field-coils of the synchronizing motor and the other will be doing no work.

图 4 展示了实施本发明的一种方便的布置。在所述图中，J J 是同步电动机的励磁线圈，H I 是转矩电动机的励磁线圈。L L' 是主线路的导体。比如说，线圈 H 的一端通过一个自感线圈 M 连接到导线 L。另一组线圈 I 的一端通过一个吸收电阻 N 连接到同一根导线上。这两个电路的相反端连接到一个开关的触点 m 上，开关的手柄或杠杆与线路导线 L' 连接。同步电动机的励磁电路的一端连接到导线 L。另一端终止于开关触点 n。从图中可以容易地看出，如果杠杆 P 被转到触点 m 上，转矩电动机将由于其两个励磁电路中的电流之间的相位差而启动。然后，当达到期望的速度时，如果杠杆 P 被移动到触点 n，全部电流将通过同步电动机的励磁线圈，另一个电动机将不做功。

The torque motor may be constructed and operated in various ways, many of which I have described in other applications; but I do not deem it necessary in illustration of the principle of construction and mode of operation of my present invention to describe these further herein. It is not necessary that one motor be cut out of circuit while the other is in, for both may be acted upon by the current at the same time, and I have devised various dispositions or arrangements of the two motors for accomplishing this. Some of these arrangements are illustrated in Figs. 5 to 9.

转矩电动机可以用各种方式构建和运行，其中的许多方式我已经在其他应用中描述过；但是我认为没有必要在此进一步描述本发明的结构原理和运行模式。没有必要在一个电动机处于电路中的同时将另一个电动机切出电路，这两个电动机可以被电流同时作用，我已经设计了这两个电动机的各种布置或安排来实现这一点。这些布置中的一些在图 5 至图 9 中已经展示。

Referring to Fig. 5, let T designate the torque or multiple-circuit motor and S the synchronizing motor, L L' being the line-wires from a source of alternating current. The two circuits of the torque motor of different degrees of self-induction, and designated by N M, are connected in derivation to the wire L. They are then joined and connected to the energizing-circuit of the synchronizing motor, the opposite terminal of which is connected to wire L'. The two motors are thus in series. To start them I short-circuit the synchronizing motor by a switch P', throwing the whole current through the torque motor. Then when the desired speed is reached the switch P' is opened, so that the current passes through

both motors. In such an arrangement as this it is obviously desirable for economical and other reasons that a proper relation between the speeds of the two motors should be observed.

参考图 5，让 T 表示转矩电动机或多电路电动机，S 表示同步电动机，L L'是来自一个交流电源的线路导线。由 N M 表示转矩电动机的两个的不同自感应度的电路，它们间接连接到导线 L。然后将它们连接到同步电动机的励磁电路上，该电路的另一端连接到导线 L'上。因此，这两个电动机是串联的。为了启动它们，我通过一个开关 P'使同步电动机短路，使整个电流流过转矩电动机。然后，当达到期望的速度时，开关 P'被断开，使得电流通过这两个电动机。在这样的一个布置中，出于经济和其他原因，显然希望观察这两个电动机的速度之间的适当关系。

In Fig. 6 another disposition is illustrated. S is the synchronizing motor and T the torque motor, the circuits of both being in parallel. W is a circuit also in derivation to the motor-circuits and containing a switch P". S' is a switch in the synchronizing-motor circuit. On the start the switch S' is opened, cutting out the motor S. Then P" is opened, throwing the entire current through the motor T, giving it a very strong torque. When the desired speed is reached, switch S' is closed and the current divides between both motors. By means of switch P" both motors may be cut out.

在图 6 中，展示出了另一种配置。S 是同步电动机，T 是转矩电动机，两者的电路是并联的。W 也是间接连接到电动机电路的一个电路，并包含一个开关 P"。S'是同步电动机电路中的一个开关。启动时，开关 S'断开，将电动机 S 切出电路。然后 P"被断开，将整个电流投入通过电动机 T，给它一个非常强的转矩。当达到所需速度时，开关 S'闭合，电流在两台电动机之间分流。通过开关 P"可以将这两个电动机切出电路。

In Fig. 7 the arrangement is substantially the same, except that a switch T' is placed in the circuit which includes the two circuits of the torque motor.

在图 7 中，除了一个开关 T'被放置在包含转矩电动机的两个电路的电路中之外，布置基本上是相同的。

Fig. 8 shows the two motors in series, with a shunt around both containing a switch ST. There is also a shunt around the synchronizing motor S, with a switch P'.

图 8 展示了串联的两个电动机，在两个电动机周围有包含开关 ST 的一个分流器。在同步电动机 S 周围也有一个带有开关 P'的分流器。

In Fig. 9 the same disposition is shown; but each motor is provided with a shunt, in which are switches P' and T", as shown.

在图 9 中，展示出了相同的布置；但是每个电动机都设有一个分流器，在该分流器中有开关 P'和 T"，如图所示。

The manner of operating the systems will be understood from the foregoing descriptions.

从前面的描述中可以理解运行系统的方式。

I do not claim herein the torque motor nor any part thereof, except in so far as they enter into the combination which forms the subject of this application, for I have made the distinguishing features of said motor the subject of other applications.

我在此不对转矩电动机或其任何部分提出主张要求，除非它们进入形成本申请主题的组合中，因为我已经将所述电动机的区别特征作为其他申请的主题。

What I now claim is—

现在我主张的是—

1. An alternating-current non-synchronizing electric motor coupled with a synchronizing alternating-current motor, substantially as set forth, whereby the former starts the latter and throws it into synchronism with its actuating-current, and switch mechanism for directing the current through either or both of the motors, as set forth.

1、一个交流非同步电动机，它与一个同步交流电动机连接在一起，基本上如所述，其中前者启动后者并使其与它的驱动电流同步，以及用于引导电流通过任一个或两个电动机的开关机制，如上所述。

2. The combination of two motors the armatures of which are mounted upon the same shaft, one of said motors being an alternating-current torque motor, or one in which the magnetic points or poles are progressively shifted by the action of the energizing-current, the other motor being an alternating-current synchronizing motor, and switch mechanism for directing the current through either or both of said motors, as set forth.

2、两个电动机的组合，它们的电枢安装在同一根轴上，所述电动机中的一个交流转矩电动机，或者其中磁点或磁极通过励磁电流的作用逐渐移动，另一个电动机是交流同步电动机，以及用于引导电流流过所述电动机中的一个电动机或两个电动机的开关机制，如上所述。

3. The combination, with an alternating-current synchronizing motor having one energizing-field, of an alternating-current torque motor having a plurality of energizing-circuits and adapted to be operated by currents differing in phase, and a switch for directing the alternating current or currents through the several circuits of one motor or the single circuit of the other, as and for the purpose set forth.

3、存在一个组合，它包括：具有一个励磁磁场的交流同步电动机；具有多个励磁电路并适于由不同相位的电流运行的交流转矩电动机；以及用于引导交流电流通过一个电动机的几个电路或另一个电动机的单个电路的一个开关，如为上述目的。

4. The combination, with an alternating-current motor having field-cores wound with coils adapted to be connected to a source of alternating currents and an armature wound with induced coils closed upon themselves, of a starting device for bringing said motor into synchronism with the generator with which it is connected.

4、一种启动装置与一个交流电动机的组合，该交流电动机的励磁线圈上缠绕有适于连接到

一个交流电源的线圈，该电动机的电枢上缠绕有自身闭合的感应线圈，该启动装置用于使所述电动机与它所连接的发电机同步。

5. The combination, with an alternating-current motor composed of a multipolar alternating field-magnet, and an armature having poles wound with coils closed upon themselves, of a starting device, as set forth.

5、一个启动装置和一个交流电动机的组合，该电动机由一个多极交替场磁体和一个电枢组成，该电枢的磁极上缠绕有自身闭合的线圈，如上所述。

6. In an alternating-current motor, the combination of a field-magnet having poles wound with coils adapted when connected with a source of alternating current to produce simultaneously opposite magnetic polarities and an armature provided with poles or projections and wound with coils connected in a continuously-closed unconnected circuit, as set forth.

6、在一个交流电动机中，存在一个组合，它包括：一个场磁体，它的磁极上缠绕有线圈，当与交流电源连接时，线圈适于同时产生相反的磁极性；一个具有磁极或突起的电枢，并缠绕有线圈，线圈被连接在一个连续闭合的非连接电路中，如上所述。

7. The herein-described method of operating alternating-current motors, which consists in actuating a motor by an alternating current to bring a second alternating-current motor up to synchronizing speed relative to the actuating-current and then switching the synchronizing motor into circuit.

7、在此描述的运行交流电动机的方法，包括利用一个交流电流驱动电动机，以使第二交流电动机达到相对于驱动电流的同步速度，然后将同步电动机切换到电路中。

NIKOLA TESLA.

尼古拉·特斯拉

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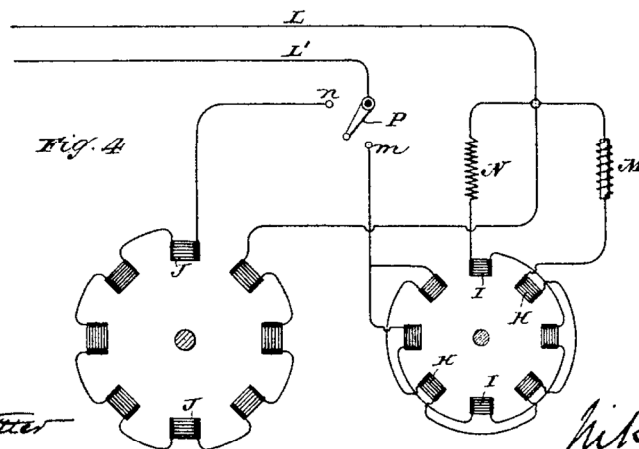
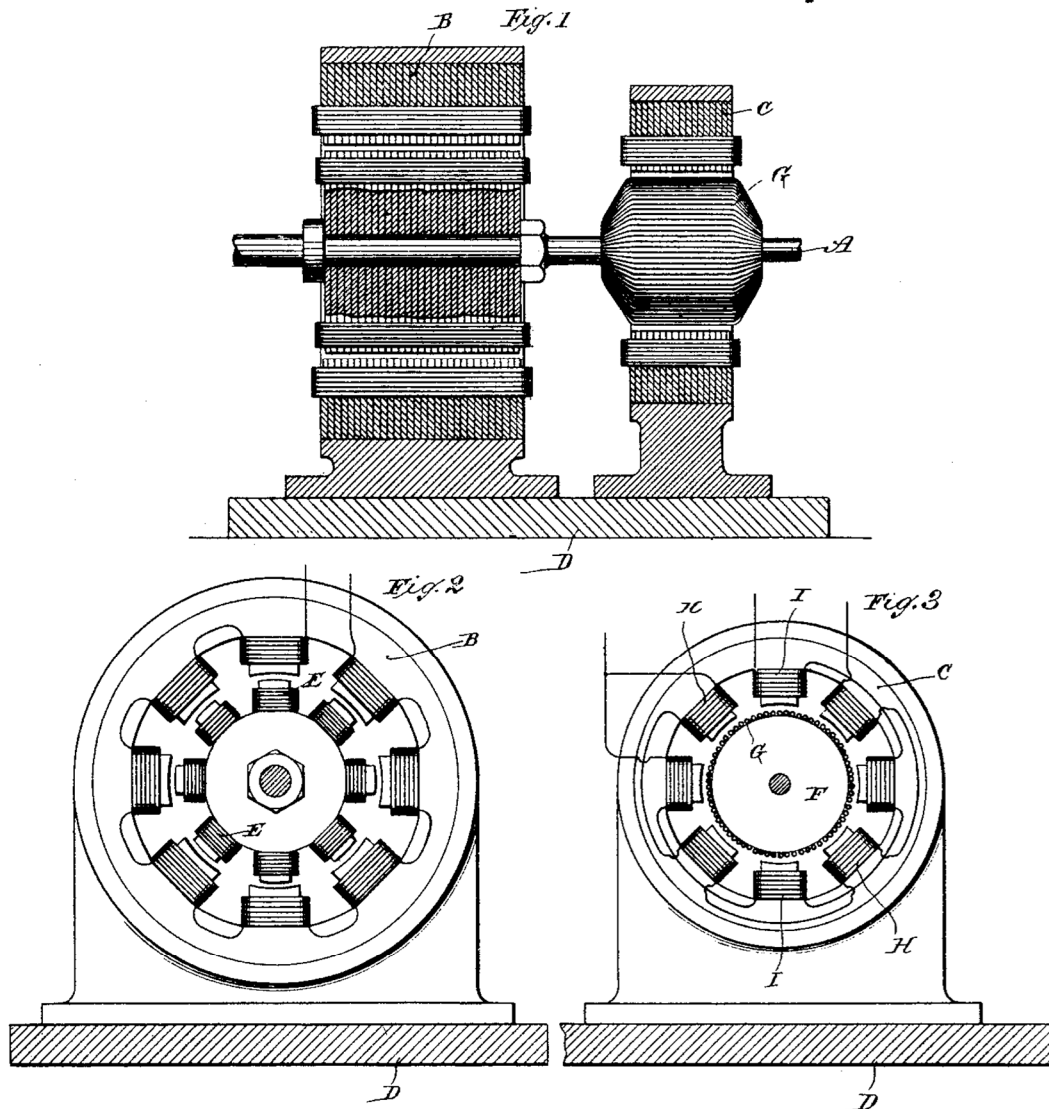
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N. TESLA.
ELECTRO MAGNETIC MOTOR.

No. 459,772.

Patented Sept. 22, 1891.



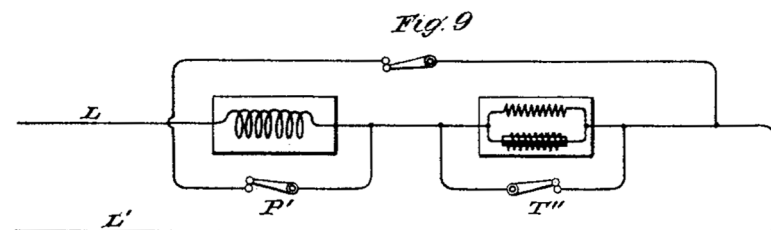
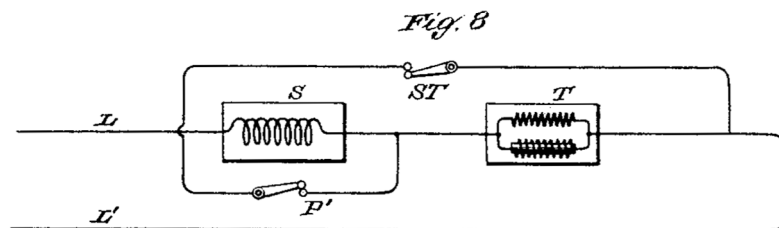
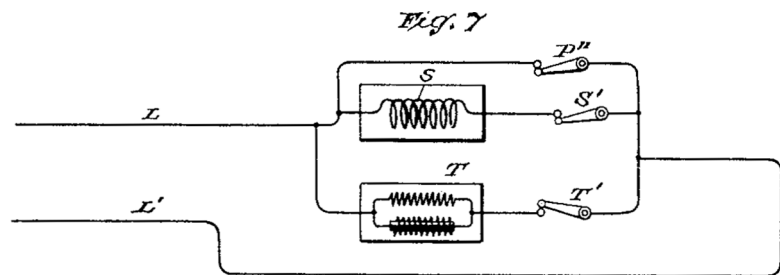
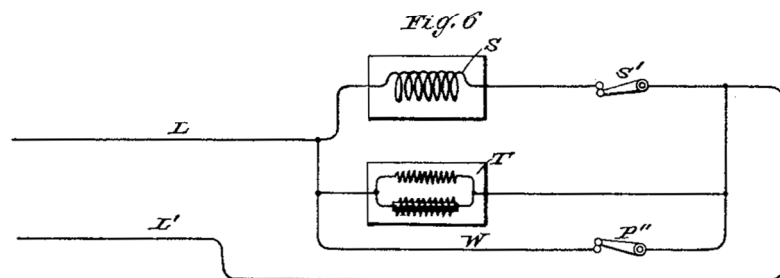
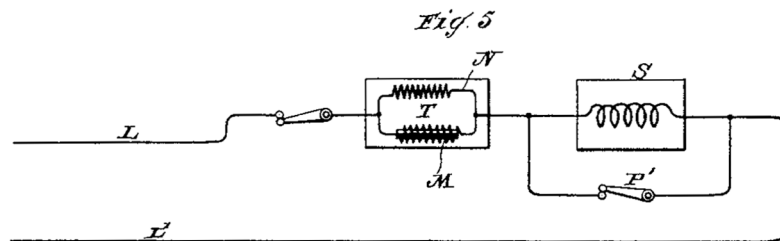
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METHOD OF AND APPARATUS FOR ELECTRICAL CONVERSION AND DISTRIBUTION.

用于电力转换和分配的方法和装置

NIKOLA TESLA, OF NEW YORK, N. Y.

纽约州纽约市的尼古拉·特斯拉

SPECIFICATION forming part of Letters Patent No. 462,418, dated November 3, 1891.

Application filed February 4, 1891. Serial No. 380,182. (No model.)

该说明书形成了颁发于 1891 年 11 月 3 日编号为 462,418 的专利证书的一部分。

申请于 1891 年 2 月 4 日提交。序列号为 380,182。(没有模型)

To all whom it may concern:

致所有相关人士:

Be it known that I, NIKOLA TESLA, a subject of the Emperor of Austria, from Smiljan, Lika, border country of Austria-Hungary, residing at New York, in the county and State of New York, have invented certain new and useful Improvements in Methods of and Apparatus for Electrical Conversion and Distribution, of which the following is a specification, reference being had to the drawings accompanying and forming a part of the same.

众所周知，我、尼古拉·特斯拉、一位奥匈帝国的臣民，来自奥匈帝国边境地区的利卡县的史密里安村，现在居住在纽约州纽约郡纽约市，在用于电力转换和分配的方法和装置方面已经发明了某些新的和有用的改进，以下是该发明一个说明书，必须参考随附的图纸，它已形成该说明书的一部分。

This invention is an improvement in methods of an apparatus for electrical conversion, designed for the better and more economical distribution and application of electrical energy for general useful purposes.

本发明是对用于电转换的装置的方法的一个改进，设计用于更好和更经济地分配和应用电能用于一般有用的目的。

My invention is based on certain electrical phenomena which have been observed by eminent scientists and recognized as due to laws which have been in a measure demonstrated, but which, so far as I am aware, have not hitherto been utilized or applied with any practically useful results. Stated briefly, these phenomena are as follows: First, if a condenser or conductor possessing capacity be charged from a suitable generator and discharged through a circuit, the discharge under certain conditions will be of an

intermittent or oscillatory character; second, if two points in an electric circuit through which a current rapidly rising and falling in strength is made to flow be connected with the plates or armatures of a condenser, a variation in the current's strength in the entire circuit or in a portion of the same only may be produced; third, the amount or character of such variation in the current's strength is dependent upon the condenser capacity, the self-induction and resistance of the circuit or its sections, and the period or time rate of change of the current. It may be observed, however, that these several factors—the capacity, the self-induction, resistance, and period—are all related in a manner well understood by electricians; but to render such conversion as may be effected by condensers practically available and useful it is desirable, chiefly on account of the increased output and efficiency and reduced cost of the apparatus, to produce current-impulses succeeding each other with very great rapidity, or, in other words, to render the duration of each impulse, alternation, or oscillation of the current extremely small. To the many difficulties in the way of effecting this mechanically, as by means of rotating switches or interrupters, is perhaps due the failure to realize practically, at least to any marked degree, the advantages of which such a system is capable. To obviate these difficulties, I have in my present invention taken advantage of the fact above referred to, and which has been long recognized, that if a condenser or a conductor possessing capacity be charged from a suitable source and be discharged through a circuit the discharge under certain conditions, dependent on the capacity of the condenser or conductor, the self-induction and resistance of the discharging circuit, and the rate of supply and decay of the electrical energy, may be effected intermittently or in the form of oscillations of extremely small period.

我的发明是基于某些电学现象，这些电学现象已被著名的科学家观察到，并被认为是由于已在一定程度上被证明的定律，但据我所知，迄今尚未利用或应用任何实际有用的结果。简言之，这些现象如下：首先，如果一个电容器或具有电容量的导体从一个合适的发电机充电并通过一个电路放电，在一定条件下放电将是间歇的或振荡的；第二，如果强度上的快速上升和下降的电流所流过的电路中的两点与电容器的极板或电容板相连，则整个电路或部分电路中的电流强度可能会发生变化；第三，电流强度的这种变化的数量或特征取决于电容器的电容量、电路或其部分的自感和电阻，以及电流变化的周期或时间速率。然而，可以观察到，这几个因素——电容量、自感、电阻和周期——都可以以电工熟知的方式相互关联；但是为了使电容器可以实现的这种转换在实际中可用和有用，主要是考虑到设备的增加的输出和效率以及降低的设备成本，需要以非常快的速度产生彼此承继的电流脉冲，或者，换句话说，要使每个脉冲、每个交替或者每个电流振荡的周期变得非常小。用机械的方法实现这一点有许多困难，如通过旋转开关或断续器，可能是由于实际上没有实现这种系统能够具有的优点，至少在任何显著的程度上没有实现。为了避免这些困难，在我的发明中，我利用了上面提到的并且长期以来被认识到的事实，即如果一个电容器或一个具有电容的导体从合适的电源充电并且通过一个电路放电，则在某些条件下的放电，取决于电容器或导体的电容量、放电电路的自感和电阻以及电能的供给速率和衰减速率，可以间歇地或者以极小周期的振荡的形式实现。

Briefly stated in general terms, the plan which I pursue in carrying out my invention is as follows: I employ a generator, preferably, of very high tension and capable of yielding either direct or alternating currents. This generator I connect up with a condenser or conductor of some capacity and discharge the accumulated electrical energy disruptively through an air-space or otherwise into a working circuit containing translating devices and, when required, condensers. These discharges may be of the same direction or alternating and intermittent, succeeding each other more or less rapidly or oscillating to and fro with extreme rapidity. In the working circuit, by reason of the condenser action, the current

impulses or discharges of high tension and small volume are converted into currents of lower tension and greater volume. The production and application of a current of such rapid oscillations or alternations (the number may be many millions per second) secures, among others, the following exceptional advantages: First, the capacity of the condensers for a given output is much diminished; second, the efficiency of the condensers is increased and the tendency to become heated reduced, and, third, the range of conversion is enlarged. I have thus succeeded in producing a system or method of conversion radically different from what has been done heretofore—first, with respect to the number of impulses, alternations, or oscillations of current per unit of time, and, second, with respect to the manner in which the impulses are obtained. To express this result, I define the working current as one of an excessively small period or of an excessively large number of impulses or alternation or oscillations per unit of time, by which I mean not a thousand or even twenty or thirty thousand per second, but many times that number, and one which is made intermittent, alternating, or oscillating of itself without the employment of mechanical devices.

概括地说，我在实施我的发明时所追求的方案如下：我采用一个发电机，最好是非常高的电压，能够产生直流电或交流电。我将该发电机与一定电容量的电容器或导体连接，并通过空气空间或其他方式将积累的电能不能破坏性地释放到包含转换装置的工作电路中，并在需要时使用电容器。这些放电可以是同向的，也可以是交替的和间歇的，或快或慢地相继发生，或极快地来回振荡。在工作电路中，由于电容器的作用，高压且小电量的电流脉冲或放电被转换成低压大电量的电流。这种快速振荡或交替的电流的产生和应用（数量可以是每秒几百万）尤其保证了以下特别的优势：首先，对于一个给定的输出，电容器的容量大大减小；第二，电容器的效率增加，变热的趋势降低，第三，转化的范围扩大。因此，我成功地创造了一种完全不同于迄今为止所做的转换系统或方法——第一，关于单位时间内电流的脉冲、交替或振荡的次数，第二，关于获得脉冲的方式。为了表达这个结果，我定义工作电流为一个极小的周期或每单位时间内数量非常大的脉冲或交替或振荡，我的意思不是每秒一千或甚至两万或三万，而是这个数字的许多倍，而且它是在不使用机械装置的情况下，由自身产生的间歇、交替或振荡。

I now proceed to an explanation somewhat more in detail of the nature of my invention, referring to the accompanying drawings.

参考附图，我现在对我的发明的本质进行更详细的解释。

The two figures are diagrams, each representing a generating-circuit, a working circuit, means for producing an intermittent or oscillating discharge, and condensers arranged or combined as contemplated by my invention.

这两幅图是示意图，每幅图代表一个发电电路、一个工作电路、用于产生间歇放电或振荡放电的装置、以及如本发明所设想的那样布置或组合的电容器。

In Figure 1, A represents a generator of high tension; B B, the conductors which lead out from the same. To these conductors are connected the conductors C of a working circuit containing translating devices, such as incandescent lamps or motors G. In one or both conductors B is a break D, the two ends being separated by an air-space or a film of insulation, through which a disruptive discharge takes place. F is a condenser, the plates of which are connected to the generating-circuit. If this circuit possess

itself sufficient capacity, the condenser F may be dispensed with.

在图 1 中，A 代表一个高压发电机；BB 是从该发电机引出的导线。这些导体与包含转换装置（例如白炽灯或电动机 G）的工作电路的导体 C 相连。在一个或两个导体 B 中有一个断路 D，其两端由空气空间或绝缘膜分开，通过该空气空间或绝缘膜发生破坏性放电。F 是一个电容器，其极板连接到发电电路。如果该电路本身具有足够的容量，电容器 F 可以省去。

In Fig. 2 the generating-circuit B B contains a condenser F and discharges through the air-gaps D into the working circuit C, to any two points of which is connected a condenser E. The condenser E is used to modify the current in any part of the working-circuit, such as L.

在图 2 中，发电电路 BB 包含一个电容器 F，并且通过空气气隙 D 放电到工作电路 C 中，到达工作电路 C 的任意的连接着电容器 E 的两点。电容器 E 用于修改工作电路（如 L）的任意部分中的电流。

It may conduce to a better understanding of the invention to consider more in detail the conditions existing in such a system as is illustrated in Fig. 1. Let it be assumed, therefore, that in the system there shown the rate of supply of the electrical energy, the capacity, self-induction, and the resistance of the circuits are so related that a disruptive, intermittent, or oscillating discharge occurs at D. Assume that the first-named takes place. This will evidently occur when the rate of supply from the generator is not adequate to the capacity of the generator, conductors B B, and condenser F. Each time the condenser F is charged to such an extent that the potential or accumulated charge overcomes the dielectric strength of the insulating space at D the condenser is discharged. It is then recharged from the generator A, and this process is repeated in more or less rapid succession. The discharges will follow each other the more rapidly the more nearly the rate of supply from the generator equals the rate at which the circuit including the generator is capable of taking up and getting rid of the energy. Since the resistance and self-induction of the working circuit C and the rapidity of the successive discharges may be varied at will, the current strength in the working and generating circuit may bear to one another any desired relation.

更详细地考虑如图 1 所示的这种系统中存在的条件会有助于更好地理解本发明。因此，假设在系统中，电路的电能供应速率、容量、自感和电阻是如此相关，以至于在 D 处发生破坏性、间歇性或振荡放电。假设发生的是破坏性放电。当发电机的供电速率不足以满足发电机、导体 BB 和电容器 F 的电容量时，这种情况显然会发生。每次电容器 F 被充电到这样的程度，使得电势或累积电荷克服 D 处绝缘空间的介电强度，导致电容器放电。然后从发电机 A 再次充电，这个过程以或多或少地快速连续重复。发电机的供电速率越接近包含发电机在内的电路能够吸收能量和释放能量的速率，放电就越快地彼此跟随。由于工作电路 C 的电阻和自感以及连续放电的速度可以随意改变，所以工作电路和发电电路中的电流强度可以相互之间具有任何所需的关系。

To understand the action of the local condenser E in Fig. 2, let a single discharge be first considered. This discharge has two paths offered—one to the condenser E, the other through the part L of the working circuit C. The part L, however, by virtue of its self-induction, offers a strong opposition to such a sudden discharge, while the condenser, on the other hand, offers no such opposition. The result is that practically no current passes at first through the branch L, but presumably opposite electricities

rush to the condenser-coatings, this storing for the moment electrical energy in the condenser. Time is gained by this means, and the condenser then discharges through the branch L, this process being repeated for each discharge occurring at D. The amount of electrical energy stored in the condenser at each charge is dependent upon the capacity of the condenser and the potential of its plates. It is evident, therefore, that the quicker the discharges succeed each other the smaller for a given output need be the capacity of the condenser and the greater is also the efficiency of the condenser. This is confirmed by practical results.

为了理解图 2 中局部电容器 E 的作用，首先考虑单次放电。这种放电有两条路径——一条到达电容器 E，另一条经过工作电路 C 的 L 部分。然而，L 部分凭借其自感，对这样一个突然放电提供了一个强烈的对抗，而电容器，另一方面，没有提供这样的对抗。结果是，实际上没有电流首先流过支路 L，但是可能相反的电流冲向电容器涂层，这暂时将电能存储在电容器中。通过这种方式获得时间，然后电容器通过支路 L 放电，这一过程在 D 处的每次放电重复进行。每次充电时储存在电容器中的电能取决于电容器的电容量及其极板的电位。因此，很明显，对于一个给定的输出，放电承继地越快，需要的电容器的容量就越小，电容器的效率也就越大。实际结果证实了这一点。

The discharges occurring at D, as stated, may be of the same direction or may be alternating, and in the former case the devices contained in the working circuit may be traversed by currents of the same or alternately-opposite direction. It may be observed, however, that each intermittent discharge occurring at D may consist of a number of oscillations in the working circuit or branch L.

如上所述，在 D 处发生的放电可以是同向的，也可以是交变的，在前一种情况下，被包含在工作电路中的设备可以流过相同或交变相反方向的电流。然而，可以观察到，在 D 处发生的每次间歇放电可以由工作电路或支路 L 中的多次振荡组成。

A periodically-oscillating discharge will occur at D in Fig. 1 when the quantities concerned bear a certain relation expressed in well-known formulae and ascertained by simple experiment. In this case it is demonstrated in theory and practice that the ratio of the strength of the current in the working to that in the generating circuits is the greater the greater the self-induction, and the smaller the resistance of the working circuit the smaller the period of oscillation.

当有关的量具有以众所周知的公式表示的并且通过简单的实验确定的某种关系时，在图 1 中的 D 处将出现一个周期性振荡放电。在这种情况下，理论和实践证明，工作电路中的电流强度与发电电路中的电流强度之比越大，自感就会越大，工作电路的阻抗也会越小，振荡周期也会越小。

I do not limit myself to the use of any specific forms of the apparatus described in connection with this invention nor to the precise arrangement of the system with respect to its details herein shown. In the drawings return-wires are shown in the circuit; but it will be understood that in any case the ground may be conveniently used in lieu of the return-wire.

我并不将自己局限于与本发明所描述相关的任何特定形式的装置的使用，也不局限于关于这里详细展示的系统的确切布置。在图中，在电路中显示出回路导线；但是应该理解，在任何情况下，接地可以方便地用来代替回线。

What I claim is—

我主张的是—

1. The method of electrical conversion herein described, which consists in charging a condenser or conductor possessing capacity and maintaining a succession of intermittent or oscillating disruptive discharges of said conductor into the working circuit containing translating devices.

1、这里描述的电转换方法，包括对具有电容量的电容器或导体进行充电，并保持所述导体向包含转换装置的工作电路进行连续间歇性放电或振荡破坏性放电。

2. In a system of electrical conversion, the combination of a generator or source of electricity and a line or generating circuit containing a condenser or possessing capacity, and a working circuit operatively connected with the generating-circuit through one or more air-gaps or breaks in the conducting medium, the electrical conditions being so adjusted that an intermittent or oscillating disruptive discharge from the generating into the working circuit will be maintained, as set forth.

2、在一个电力转换系统中，存在一个组合，它包括：一个发电机或一个电源和包含一个电容器或具有电容量的一个线路或发电电路；以及通过导电介质中的一个或多个气隙或间隙与发电电路进行可操作地连接的工作电路，电气条件被调整为使得从发电电路到工作电路的间歇放电或振荡破坏性放电将被维持，如前所述。

NIKOLA TESLA.

尼古拉·特斯拉

Witnesses:

ROBT. F. GAYLORD,

PARKER W. PAGE.

见证人:

罗伯特·F·盖洛德、帕克·W·佩奇。

(No Model.)

N. TESLA.

METHOD OF AND APPARATUS FOR ELECTRICAL CONVERSION AND
DISTRIBUTION.

No. 462,418.

Patented Nov. 3, 1891.

Fig. 1

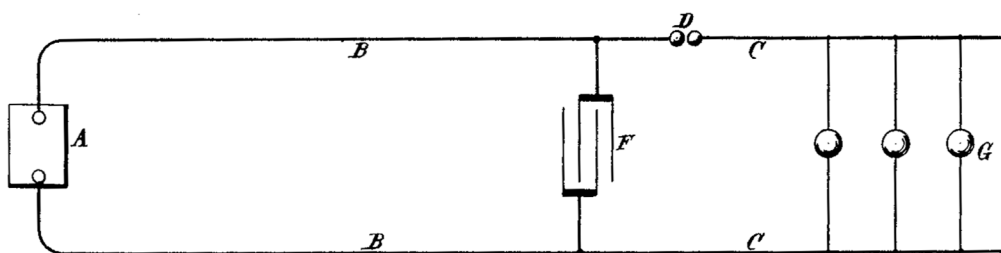
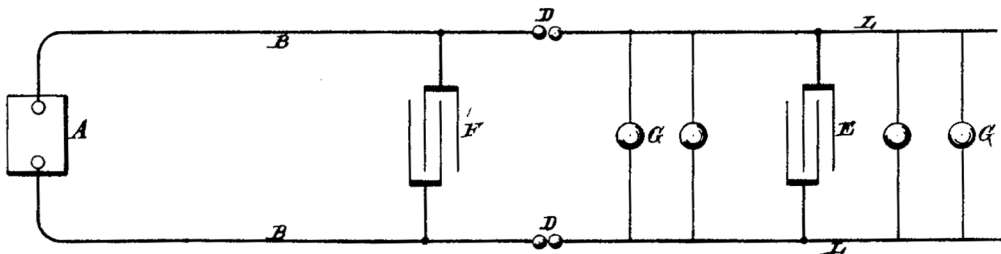


Fig. 2



Witnesses:

Raphael Netter
Frank B. Murphy.

Inventor

Nikola Tesla
by *Duncan Hage.*
Attorneys.

ELECTRO-MAGNETIC MOTOR.

电磁电动机

NIKOLA TESLA, OF NEW YORK, N. Y.

纽约州纽约市的尼古拉·特斯拉

SPECIFICATION forming part of Letters Patent No. 464,666, dated December 8, 1891.

Application filed July 13, 1891. Serial No. 399,312. (No model.)

该说明书形成了颁发于 1891 年 12 月 8 日编号为 464,666 的专利证书的一部分。

申请于 1891 年 7 月 13 日提交。序列号为 399,312。(没有模型)

To all whom it may concern:

致所有相关人士:

Be it known that I, NIKOLA TESLA, a subject of the Emperor of Austria, from Smiljan, Lika, border country of Austria-Hungary, residing at New York, in the county and State of New York, have invented certain new and useful Improvements in Electro-Magnetic Motors, of which the following is a specification, reference being had to the drawing accompanying and forming part of the same.

众所周知,我、尼古拉·特斯拉、一位奥匈帝国的臣民,来自奥匈帝国边境地区的利卡县的史密里安村,现在居住在纽约州纽约郡纽约市,在电磁电动机方面已经发明了某些新的和有用的改进,以下是该发明一个说明书,必须参考随附的图纸,它已经形成了该说明的一部分。

The general object of my present invention is to secure artificially a difference of a quarter of a phase between the currents in the two energizing-circuits of an alternating-current electro-magnetic motor of that general class invented by me, in which the action or operation is dependent upon the inductive influence upon a rotating armature of independent field magnets or coils exerted successively and not simultaneously.

我的发明的总的目的是人为地确保我发明的那种普通类型的交流电磁电动机的两个励磁电路中的电流之间的四分之一相位差,该电动机的动作或运行取决于相继的而不是同时的施加在独立的场磁体或线圈的一个旋转电枢上的感应影响。

It is a well-known fact that if the field or energizing circuits of such a motor be both derived from the same source of alternating currents and a condenser of proper capacity be included in one of the same, approximately the desired difference of phase may be obtained between the currents flowing directly from the source and those flowing through the condenser; but the great size and expense of condensers for this purpose that would meet the requirements of the ordinary systems of comparatively low potential are practically prohibitory to their employment.

众所周知,如果这种电动机的磁场或励磁电路都来自相同的交流电源,并且在其中一个电路中包含适当电容量的一个电容器,则可以在直接从电源流出的电流和流过电容器的电流之间

获得近似期望的相位差；使用该电容器的目的将满足相对较低电势的普通系统的要求，但用于此目的电容器的巨大尺寸和费用实际上禁止了它们的使用。

Another now well-known method or plan of securing a difference of phase between the energizing-currents of motors of this kind is to induce by the currents in one circuit those in the other circuit or circuits; but no means have heretofore been proposed that would secure in this way between the phases of the primary or inducing and the secondary or induced currents that difference—theoretically ninety degrees—that is best adapted for practical and economical working.

另一种现在众所周知的确保这种类型的电动机的励磁电流之间的一个相位差的方法或方案是通过一个电路中的电流来感应出其他电路中的电流；但是迄今为止还没有提出任何方法来以这种方式确保初级电流或施感电流与次级电流或感应电流之间的相位差——理论上 90 度最适于实际和经济的工作。

I have devised a means which renders practicable both the above-described plans or methods, and by which I am enabled to obtain an economical and efficient alternating-current motor, my invention consisting in placing a condenser in the secondary or induced circuit of the motor above described and raising the potential of the secondary currents to such a degree that the capacity of the condenser, which is in part dependent on the potential, need be quite small. The value of this condenser will be determined in a well-understood manner with reference to the self-induction and other conditions of the circuit, so as to cause the currents which pass through it to differ from the primary currents by a quarter-phase.

我已经设计了一种使上述几种方案或方法都可行的工具，通过该工具，我能够获得一种经济有效的交流电动机，我的发明包括在上述电动机的次级或感应电路中放置一个电容器，并且将次级电流的电势提高到一定程度，使得部分地取决于电势的电容器的电容量只需要非常小。这个电容器的容量值将参照电路的自感和其它条件以众所周知的方式确定，以便使通过它的电流与初级电流相差四分之一相位。

The drawing is a partly-diagrammatic illustration of a motor embodying my invention.

附图是体现我的发明的电动机的部分示意图。

I have illustrated the invention as embodied in a motor in which the inductive relation of the primary and secondary circuits is secured by winding them inside the motor partly upon the same cores; but it will be understood that the invention applies, generally, to other forms of motor in which one of the energizing-currents is induced in any way from the other.

我已经将本发明的描述体现在一个电动机中，该电动机的初级电路和次级电路的感应关系通过将它们部分地缠绕在电动机内部的相同铁芯上来确保；但是应当理解，本发明通常适用于其它形式的电动机，这种形式的电动机的励磁电流中的一个是以任何方式从另一个励磁电流中感应生成的。

Let A B represent the poles of an alternating-current motor, of which C is the armature wound with coils D, closed upon themselves, as is now the general practice in motors of this kind. The poles A, which alternate with poles B, are wound with coils of ordinary or coarse wire E in such direction as to

make them of alternate north and south polarity, as indicated in the diagram by the characters N S. Over these coils or in other inductive relation to the same are wound long fine-wire coils F F and in the same direction throughout as the coils E. These coils are secondaries, in which currents of very high potential are induced. I prefer to connect all the coils E in one series and all the secondaries F in another.

让 A B 代表一个交流电动机的两极，其中 C 是电枢，上面缠绕有线圈 D，它们自身闭合，这是目前这类电动机的通常做法。与磁极 B 交替的磁极 A，用普通导线或粗导线 E 的线圈沿这样的方向缠绕，以使它们具有交替的北极和南极，如图中字符 NS 所示。在这些线圈上或与这些线圈有其它感应关系的是用细长导线缠绕的线圈 FF，并且与线圈 E 的方向完全相同。这些线圈是次级线圈，在其中能感应出很高电位的电流。我更喜欢把所有的线圈 E 串联成一组串联，把所有的次级线圈 F 串联成另一组串联。

On the intermediate poles B are wound fine-wire energizing-coils G, which are connected in series with one another and also with the series of secondary coils F, the direction of winding being such that a current-impulse induced from the primary coils E imparts the same magnetism to the poles B as that produced in poles A by the primary impulse. This condition is indicated by that character N' S'.

在中间磁极 B 上缠绕有细导线励磁线圈 G，这些线圈彼此串联连接，并且还与次级线圈 F 串联连接，线圈 F 的缠绕方向使得从初级线圈 E 感应出的一个电流脉冲向磁极 B 一个磁性，该磁性与初级脉冲在磁极 A 中产生的磁性相同。这种情况由字符 N' S' 表示。

In the circuit formed by the two sets of coils F and G is introduced a condenser H; otherwise the said circuit is closed upon itself, while the free ends of the circuit of coils E are connected to a source of alternating currents. As the condenser capacity which is needed in any particular motor of this kind is dependent upon the rate of alternation or the potential, or both, its size or cost, as before explained, may be brought within economical limits for use with the ordinary circuits if the potential of the secondary circuit in the motor be sufficiently high. By giving to the condenser proper values any desired difference of phase between the primary and secondary energizing-circuits may be obtained.

在由两组线圈 F 和 G 形成的电路中引入了一个电容器 H；否则，所述电路自身闭合，而线圈 E 的电路的游离端连接到一个交流电源。由于在这种类型的任何特定电动机中所需的电容器容量取决于交变的速率或者电势，或两者都有，所以如前所述，如果在电动机中次级电路的电势足够高，则电容器的尺寸或成本可以在普通电路使用的经济限度内。通过给电容器适当的值，可以获得初级励磁电路和次级励磁电路之间的任何期望的相位差。

What I claim is—

我主张的是—

1. In an alternating-current motor provided with two or more energizing or field circuits, one of which is adapted for connection with a source of currents and the other or others in inductive relation thereto, the combination, with the secondary or induced circuit or circuits, of a condenser interposed in the same, as set forth.

1、在配备有两个或多个励磁电路的交流电动机中，其中一个电路适于与电流源连接，另一

个或其他电路与电流源成感应关系,以及一个或多个次级电路或被感应的电路与插入其中的一个电容器的组合,如上所述。

2. In an alternating-current motor, the combination of two energizing-circuits, one connected or adapted for connection with a source of alternating currents, the other constituting a high-potential secondary circuit in inductive relation to the first, and a condenser interposed in said secondary circuit, as set forth.

2、在一个交流电动机中,存在着由两个励磁电路形成的组合,一个电路与一个交流电源连接或适于与一个交流电源连接,另一个电路构成与第一个电路有感应关系的高电位次级电路,一个电容器插入所述次级电路中,如上所述。

NIKOLA TESLA.
尼古拉·特斯拉

Witnesses:

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ERNEST HOPKINSON.

见证人:

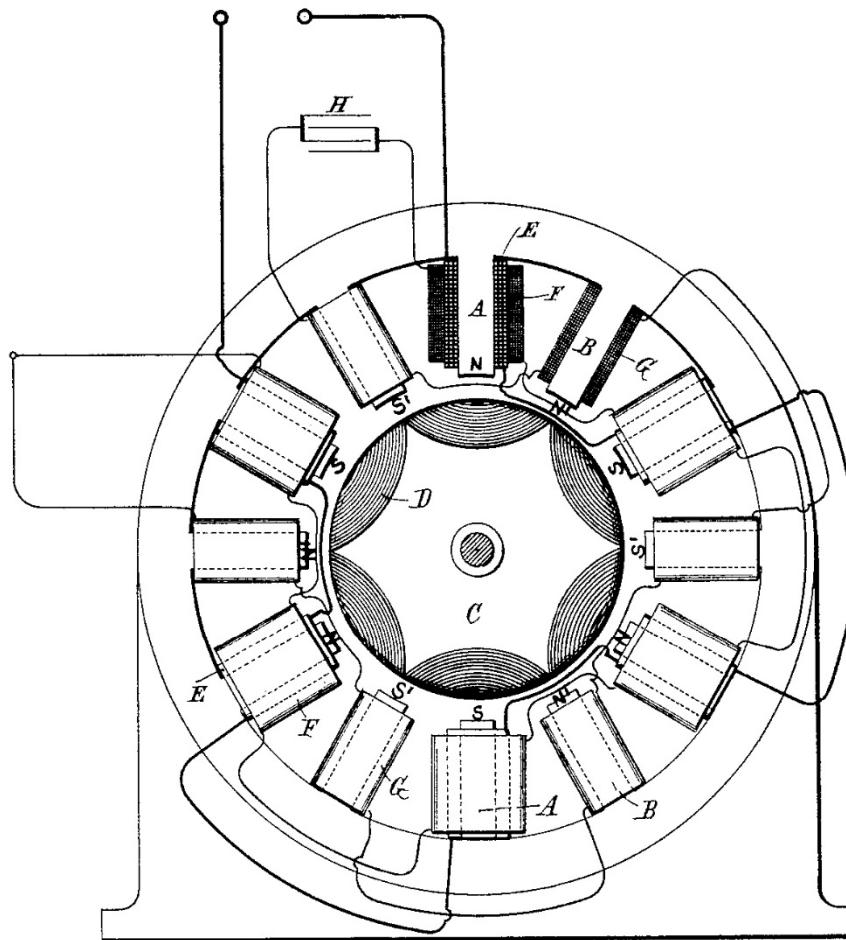
罗伯特·F·盖洛德、欧内斯特·霍普金森。

(No Model.)

N. TESLA.
ELECTRO MAGNETIC MOTOR.

No. 464,666.

Patented Dec. 8, 1891.



Witnesses:

Raphael Netter
Frank B. Murphy

Inventor

Nikola Tesla
by
Duncan & Page
Attorneys

IMPROVEMENTS IN ALTERNATING CURRENT ELECTRO-MAGNETIC MOTORS

交流电磁电动机的改进

No 11,473 A.D. 1891
编号 11,473 公元 1891 年

Date of Application, 6th July, 1891 - Accepted, 22nd Aug., 1891
1891 年 7 月 6 日申请-1891 年 8 月 22 日被接受

Communicated from abroad by Nikola Tesla, of Astor House, New York,
United States of America, Electrician.
居住在美国纽约市礼查饭店的电气技师尼古拉·特斯拉发来的通讯。

COMPLETE SPECIFICATION. 完整说明

I, Henry Harris Lake, of the firm of Haseltine Lake & Co., Patent Agents, 45 Southamton Buildings, in the County of Middlesex, do hereby declare the nature of this invention and in what manner the same is to be performed to be particularly described and ascertained in and by the following statement :-

本人、亨利·哈里斯·雷克，来自英国密得塞斯郡南安普顿大厦 45 号哈兹尔廷（雷克）专利代理公司，特此声明本发明的性质以及以何种方式执行本发明，并在以下声明中具体说明和确定：

This invention relates to electric motors, the action or operation of which is dependent upon the inductive influence upon, and magnetization of a rotating armature by independent field magnets or coils traversed by alternating or similar currents, which produce their effect upon said armature not simultaneously but successively, as would result from said currents being of different phase.

本发明涉及到电动机，其动作或运行取决于由交变电流或类似电流所流经的独立的场磁体或励磁线圈对旋转电枢的感应影响和磁化，交变电流或类似电流不是同步地而是连续地对所述电枢产生影响，这将由所述不同相位的电流产生。

The improvements consist in a novel arrangement applicable to motors, in which the current for one of the energizing circuits is obtained by induction from the other, and also in a means for increasing the flow of current in the closed induced armature coils of any form of alternating current motor in which such coils may be present, particularly, in what are now known as the Tesla motors.

改进之处包括一种适用于电动机的新颖装置，该电动机中的多个励磁电路中的一个励磁电路

的电流由另一个励磁电路感应获得,并且包括一种用于增加交流电动机的任何形式的闭合感应电枢线圈中的电流的手段,在这些交流电动机中可以存在这种线圈,特别是在现在已知的特斯拉电动机中。

The first feature above referred to is the placing in the secondary or induced field or energizing circuit of the motor a condenser, adjusting it so as to neutralize the self induction to the desired extent, and to secure between the primary and the secondary currents the proper difference of phase for the most economical operation of the motor; and the second is the interposition of a condenser in the induced or what is otherwise the closed circuit of the armature.

上面提到的第一个特征是在电动机的次级或感应磁场或励磁电路中放置一个电容器,调节它以便将自感抵消到所期望的程度,并确保初级电流和次级电流之间适当的相位差,以便电动机最经济地运行;第二是在电枢的感应电路或闭合电路中插入一个电容器。

In the accompanying drawings

在附图中

Figure 1 is a form of induction motor to which the improvements are applied.

图 1 是感应电动机的一种形式,对其进行了改进。

Figure 2 is a diagram of a modification of a part of the improvements.

图 2 是所述改进的一部分的一个修改的示意图。

The motor is composed of two or more pairs or sets of field magnets, A and B, mounted in or forming part of a suitable frame and a rotary armature wound with a coil C.

电动机由两对(组)或多对(组)场磁体 A 和 B 以及缠绕有一个线圈 C 的旋转电枢组成,场磁体 A 和 B 被安装在合适的框架中或形成合适框架的一部分。

In the particular motor here shown, the coils on two opposite poles, as A, are connected directly to a main or branch circuit D from a generator of alternating currents. Over, or in any other inductive relation to these coils, secondary coils E are wound, and in the circuit of these are included the energizing coils F of the other pair of field poles B. Hence, the alternating currents that energize the poles A, induce currents that energize poles B, but no means have heretofore been proposed that would secure between the phases of the primary or inducing and the secondary or induced currents that difference of phase, theoretically ninety degrees, that is best adapted for practical and economical working.

在这里所示的特定电动机中,两个相反磁极上的线圈(如 A)被直接连接到源自一个交流发电机的一个主电路或分支电路 D。次级线圈 E 被缠绕在这些线圈上或与这些线圈成任何其它感应关系,并且在这些线圈的电路包括另一对场磁极 B 的励磁线圈 F。因此,励磁磁极 A 的交流电流感应出场磁极 B 的电流,但是迄今为止还没有提出任何措施来保证初级电流

或施感电流和次级电流或感应电流的相位之间的相位差，理论 90 度是最适合于实际和经济的工作。

To more perfectly secure this object, I interpose in the secondary circuit, or that which includes the coils E, F, a condenser G, adjusting it as to capacity in well-known ways so as to neutralize or overcome the retarding effect of self induction and bring the phase more nearly to the proper point of difference.

为了更好地实现这个目标，我在次级电路中或包含线圈 EF 的电路中插入一个电容器 G，以众所周知的方式调整它的电容量，以便抵消或克服自感的延迟效应，使相位更接近正确的相差点。

As the required capacity of this condenser is dependent upon the rate of alternation or the potential or both, its size and cost may be brought within economical limits, for use with the ordinary circuits by raising the potential of the secondary circuit in the motor. Many turns of fine wire are therefore used for the coils E, so as to convert to a current of very high potential.

由于这种电容器所需的容量取决于交变速率或电势或两者都有，所以它的尺寸和成本可以被控制在经济的限度内，以便通过提高电动机中次级电路的电势来与普通电路一起使用。因此，许多细导线的匝圈用于线圈 E，以便转换成非常高电位的电流。

This improvement is equally applicable to motors of this type, that is to say, - those in which the currents for one energizing circuit are induced from the other when a distinct transformer outside of the motor is used. In the illustration, the two energizing circuits are brought into inductive relation inside the motor, but it is evident that they may be brought into the same relation outside the motor by means of a transformer.

这种改进同样适用于这种类型的电动机，也就是说，当在那些电动机外部使用一个本质上不同的变压器时，电动机中的一个励磁电路的电流是从另一个励磁电路感应产生的。在图示中，两个励磁电路在电动机内部形成感应关系，但是显然它们可以通过一个变压器在电动机外部形成相同的关系。

In this, as well as in all other forms of motor in which a closed armature coil is used, in which currents are induced by the action of the field magnets or coils, the most efficient working conditions require, that, for a given inductive effect upon the armature there should be the greatest possible current through the armature or induced coils, and, also, that there should always exist between the currents in the energizing and the induced circuits, a given relation or difference of phase hence, whatever tends to decrease the self-induction and increase the current in the induced circuit will, other things being equal, increase the output and efficiency of the motor, and the same will be true of causes that operate to maintain the mutual attractive effect between the field magnets and armature at its maximum.

在这种情况下，以及在使用一个闭合的电枢线圈的所有其它形式的电动机中，电枢线圈中的电流由场磁体或励磁线圈的作用感应产生，对于电枢上的给定感应效应，最有效的工作条件要求应该是通过电枢线圈或感应线圈的最大可能的电流，并且，在励磁电路和感应电路中的电流之间因此应该总是存在一个给定的相位关系或相位差，不管是什么倾向于降低自感和增加感应电路中的电流，在其他条件相同的情况下，都将增加电动机的输出和效率，并且同样

的原因也适用于将场磁铁和电枢之间的相互吸引效应保持在最大值的情况。

These results are secured by connecting with the induced or armature circuit H of the armature a condenser L. This coil or coils H have no connection with the outside circuit and are closed upon themselves through the condenser. In ordinary cases, the terminals of the coils lead to collecting rings M, M, upon which brushes N, N, bear, and the condenser is inserted between these brushes. But the armature core may be hollow and the condenser carried within it, or the sheet-iron plates, of which the core is composed, may be carefully insulated so as to constitute a condenser, and the coils may be connected to the plates. In such cases no brushes would be required.

通过在感应电路或电枢电路 H 上连接一个电容器 L 来确保这一结果。这个线圈 H 或这些线圈 H 没有与外部电路连接，并且通过电容器自我闭合。在通常情况下，线圈的终端通向集电环 MM，电刷 NN 倚靠在集电环 MM 上，并且电容器被插入在这些电刷之间。但是电枢磁芯可以是中空的，并且其中携带有电容器，或者组成磁芯的薄铁板可以被小心地绝缘以构成一个电容器，并且线圈可以连接到这些板上。在这种情况下，不需要电刷。

The condenser should be of such character as to overcome the self-induction of the armature, so that when the motor is in operation the impedance of the said coils to the passage of the induced currents is not only neutralized, but the phases of the induced currents are brought more nearly into proper accord with those in the field coils.

电容器应具有克服电枢自感的特性，这样，当电动机运行时，所述线圈阻碍感应电流通过的阻抗不仅被抵消，而且感应电流的相位与励磁线圈中的相位更接近适当的一致。

In motors in which the armature coils are closed upon themselves, as, for example, in any form of alternating current motor in which one armature coil or set of coils is in the position of maximum induction with respect to the field coils or poles, while the other is in the position of minimum induction, the coils are preferably connected in one series and two points of the circuit thus formed are bridged by a condenser. This is illustrated in Figure 2, in which P represents one set of armature coils and P¹ the other. Their points of union are joined through a condenser G.

在电枢线圈自身闭合的电动机中，例如在任何形式的交流电动机中，一个电枢线圈或一组线圈相对于励磁线圈或磁极处于最大感应位置，而另一个电枢线圈处于最小感应位置，这些线圈最好串联连接，这样形成的电路的两点可以通过电容器桥接。如图 2 所示，其中 P 代表一组电枢线圈，P¹ 代表另一组。它们的结合点通过一个电容器 G 连接起来。

It will be observed that in this disposition the self-induction of the two branches P and P¹ varies with their position relatively to the field magnet, and that each branch is alternately the predominating source of the induced current, hence the effect of the condenser G is two-fold. Firstly, it increases the current in each of the branches alternately and secondly it alters the phase of the currents in the branches, this being the well-known effect which results from such a disposition of a condenser with a circuit as above described.

将观察到，在这种配置中，两个分支 P 和 P¹ 的自感随着它们相对于场磁体的位置而变化，并且每个分支交替地成为感应电流的主电源，因此电容器 G 的效果是双重的。首先，它交

替地增加每个分支中的电流，其次，它改变分支中电流的相位，这是众所周知的效果，这是由具有上述电路的电容器的这种布置所产生的。

This effect is favorable to the proper working of the motor because it increases the flow of current in the armature circuits due to a given inductive effect, and also because it brings more nearly into coincidence the maximum magnetic effects of the co-acting field and armature poles.

这种效果有利于电动机的正常工作，因为由于一个给定的感应效应，这种效果增加了电枢电路中的电流，还因为这种效果使共同作用的磁场的和电枢的磁极的最大磁效应更加接近实时重合。

Although this feature of the invention has been illustrated herein, in connection with a special form of motor, it will be understood that it is equally applicable to any other alternating current motor in which there is a closed armature coil wherein the currents are induced by the action of the field, and, furthermore, I would state also that the feature of utilizing the plates or sections of a magnetic core for forming the condenser, I regard as applicable, generally, to other kinds of alternating current apparatus.

虽然本发明的这一特征已经在这里结合一种特殊形式的电动机进行了说明，但是应当理解，它同样适用于任何其它的交流电动机，在这些电动机中有一个闭合的电枢线圈，在该线圈中电流是由磁场的作用而感应产生的，而且，我还要说明，利用磁芯的板或分段来构成电容器的这种特征，我认为通常适用于其它种类的交流设备。

Having now particularly described and ascertained the nature of the said invention and in what manner the same is to be performed, as communicated to me by my foreign correspondent, I declare that what I claim is :-

现在已经特别描述和确定了上述发明的性质和以何种方式执行上述发明，我的外国通信者传达给我，我宣布我主张的是：—

First. In an alternating current motor in which one energizing circuit is in inductive relation to the other and closed upon itself, the combination with such closed or secondary circuit of a condenser interposed in the same, as described.

第一、在一个交流电动机中，一个励磁电路与另一个励磁电路具有感应关系，并且自身闭合，这样闭合的电路或者次级电路以及被插入在该电路中的一个电容器的组合，如上所述。

Second. In an alternating current motor, the combination of two energizing circuits, one connected or adapted for connection with a source of alternating currents, the other constituting a secondary circuit in inductive relation to the first and adapted to convert to currents of high potential, and a condenser interposed in the said secondary circuit, as set forth.

第二、在一个交流电动机中，存在一个组合，它包括：两个励磁电路，一个与交流电源连接或适于与交流电源连接，另一个构成与第一个电路成感应关系的次级电路，适于转换成高电位电流；以及插入所述次级电路中的电容器，如上所述。

Third. In an alternating current motor, the combination with the armature and an energizing circuit formed by a coil or conductor wound thereon in inductive relation to the field, of a condenser connected to the said coil or conductor.

第三、在一个交流电动机中，存在一个组合，它包括：电枢和一个励磁电路，该励磁电路由与磁场成感应关系的一个线圈或一个绕制的导体来构成；与所述线圈或导体相连的一个电容器。

Fourth. In an alternating current motor, the combination with armature coils in inductive relation to the field and connected in a closed circuit, of a condenser bridging said circuit, as set forth.

第四、在一个交流电动机中，存在一个组合，它包括：与磁场成感应关系的电枢线圈，并且这些电枢线圈在一个闭合的电路中相连；桥接所述电路的一个电容器，如上所述。

Fifth. In an alternating current motor, the combination with the induced energizing coil or coils of the armature of a condenser connected therewith and made a part of the armature or rotating element of the motor.

第五、在交流电动机中，被感应（感生）的励磁线圈或电容器电枢线圈与连接所述线圈的一个电容器的组合，该电容器构成电动机电枢或旋转组件的一部分。

Dated this 4th day of July 1891.

1891 年 7 月 4 日申请。

Haseltine, Lake & Co.,
45, Southampton Buildings, London, W.C., Agents for the Applicant.

哈兹尔廷（雷克）公司
伦敦西中央区南安普敦大厦 45 号，代理申请。

Fig. 1

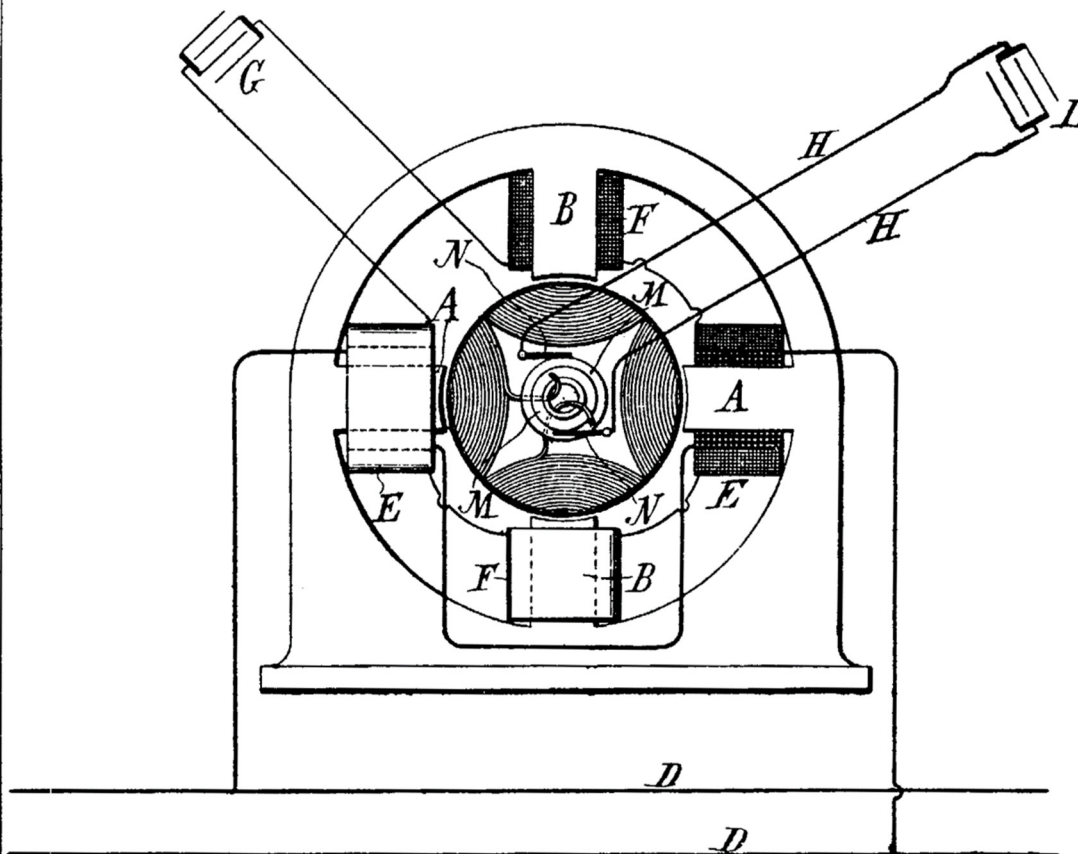
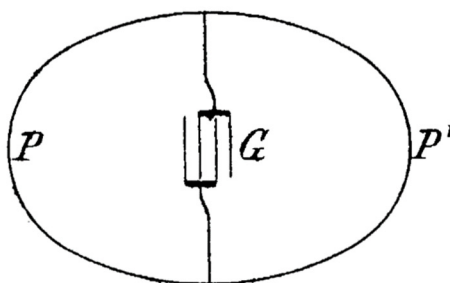


Fig. 2



[This Drawing is a reproduction of the Original on a reduced scale.]

SYSTEM OF ELECTRICAL TRANSMISSION OF POWER.

电力传输系统

NIKOLA TESLA, OF NEW YORK, N. Y., ASSIGNOR TO THE TESLA ELECTRIC
COMPANY, OF SAME PLACE.

纽约州纽约市的尼古拉·特斯拉将专利权转让给纽约市的特斯拉电气公司

SPECIFICATION forming part of Letters Patent No. 487,796 dated December 13, 1892.

Application filed May 15, 1888. Serial No. 273,992. (No model.)

该说明书形成了颁发于 1892 年 12 月 13 日编号为 487,796 的专利证书的一部分。

申请于 1888 年 5 月 15 日提交。序列号为 273,992。(没有模型)

To all whom it may concern:

致所有相关人士:

Be it known that I, NIKOLA TESLA, a subject of the Emperor of Austria, from Smiljan, Lika, border country of Austria-Hungary, but now residing at New York, in the county and State of New York, have invented certain new and useful Improvements in Systems for Electrical Transmission of Power, of which the following is a specification, reference being had to the drawings accompanying and forming a part of the same.

众所周知,我、尼古拉·特斯拉、一位奥匈帝国的臣民,来自奥匈帝国边境地区的利卡县的史密里安村,现在居住在纽约州纽约郡纽约市,在电力传输系统方面已经发明了某些新的和有用的改进,以下是该发明一个说明书,必须参考随附的图纸,它已形成该说明书的一部分。

This invention is an improvement in systems of electrical distribution of power wherein are employed motors having two or more independent energizing-circuits, through which are passed alternating currents differing in phase that are produced by a magneto-electric machine having independent induced circuits, or that are obtained from any other suitable source or by any other suitable means. In illustration of the various conditions which I regard as most important to an attainment of the best results from the use of motors of this character, I have heretofore used generally forms of generator in which the relations of the induced or current-generating coils and field-magnets were such that but two impulses or current are produced in each coil by a single revolution of the armature or field cores. The rate, therefore, at which the different phases or impulses of current in the line-circuits succeeded one another was so little greater than that at which the armature of the generator revolved that without special provision the generator required to be run at very high speed to obtain the best results. It is well known that the most efficient results are secured in the operation of such motors when they are run at high speeds; but as the practicable rate of speed is much limited by mechanical conditions, particularly in the case of large generators, which would be required when a number of motors are run from a single source, I have sought to produce a greater number of current impulses by a slow or slower speed than

that at which the ordinary bipolar-machines may be economically operated. I therefore adapt to my system any of the various types of multipolar alternating-current machines which yield a considerable number of current reversals or impulses for each revolution of the armature by observing the main condition essential to the operation of my system that the phases of the currents in the independent induced circuits of the generator should not coincide, but exhibit a sufficient difference in phase to produce the desired results. I may accomplish this in a variety of ways, which, however, vary only in detail, since they are based upon the same underlying principle. For example, to adapt a given type of alternating-current generator I may couple rigidly two complete machines, securing them so that the requisite difference in phase between the currents produced by each will be obtained, or I may secure two armatures to the same shaft within the influence of the same field and with angular displacement that will produce the proper difference in phase between the two currents, or I may secure two armatures to the same shaft with their coils symmetrically disposed, and place two sets of field-magnets at such angle as to secure the same result, or, finally, I may wind on the same armature the two sets of coils alternately, or in such manner that they will develop currents, the phases of which differ in time sufficiently to produce rotation of the motor.

本发明是对配电系统的改进，其中采用了具有两个或多个独立励磁电路的电动机，由具有独立感应电路的磁电机产生的或从任何其他合适的电源或通过任何其他合适的措施获得的不同相位的交流电通过该电动机。在说明各种条件下，我认为最重要的是从使用这种特性的电动机获得最佳结果，我迄今为止使用一般形式的发电机，其中的感应线圈或电流产生线圈和场磁体的关系是这样的，由电枢或励磁铁芯的单个旋转在每一个线圈中只产生两个脉冲或电流。因此，电流的不同相位或脉冲在线路电路中相继发生的速率比发电机电枢旋转的速率大不了多少，如果没有特殊规定，发电机需要以非常高的速度运行才能获得最好的结果。众所周知，当这种电动机以高速运行时，其运行效率最高；但实际可行的速度受到机械条件的限制，特别是在大型发电机的情况下，当许多电动机由一个单一的电源运行时，这将是必需的，我已经寻求通过一个慢的速度来产生更大数量的电流脉冲，这个速度要比普通的双极机器可以经济地运行的速度更慢。我通过观察对我的系统的运行至关重要的主要条件，即在发电机的独立感应电路中的电流相位不该在时间上重合，但表现出足够的相位差来产生预期的结果，我因此将各种类型的多极交流电机的任何一种适用于我的系统，这些交流电机可以为电枢的每此旋转产生相当数量的电流反转或脉冲。我可以用各种方法来实现这一点，然而，这些方法只是在细节上有所不同，但它们都是基于相同的基本原理。例如，为了适用于一个给定类型的交流发电机，我可以刚性地连接两个完整的机器，固定它们，从而将获得由每个机器产生的电流之间的必要相位差，或者我可以将两个电枢固定到同一轴上，在同一磁场的影响下，并且具有将在两个电流之间产生适当相位差的角位移，或者我可以将两个电枢固定在同一轴上，它们的线圈对称放置，并以这样的角度放置两组场磁体以确保相同的结果，或者，最后，我可以在同一电枢上交替地缠绕两组线圈，或者以这样的方式，它们将产生电流，这些电流的相位在时间上的差异足以产生电动机的旋转。

Another feature of my invention is in the plan which I have devised for utilizing generators and motors of this type, whereby a single generator may be caused to run a number of motors either at the same speed as its own or all at different speeds. This I accomplish by constructing the motors with fewer poles than the generator, in which case their speed will be greater than that of the generator, the rate of speed being higher as the number of their poles is relatively less. This will be understood from an example. Suppose the generator has two independent generating-coils which revolve between two pole-pieces oppositely magnetized and that the motor has energizing-coils that produce at any given time

two magnetic poles in one element that tend to set up a rotation of the motor. A generator thus constructed yields four impulses or reversals of current by each revolution, two in each of its independent circuits, and I have demonstrated that the effect upon a motor such as that mentioned is to shift the magnetic poles through three hundred and sixty degrees. It is obvious that if the four reversals in the same order could be produced by each half-revolution of the generator the motor would make two revolutions to the generator's one. This would be readily accomplished by adding two intermediate poles to the generator or altering it in any of the other equivalent ways above indicated. The same rule applies to generators and motors with multiple poles. For instance, if a generator be constructed with two circuits, each of which produces twelve reversals of current to a revolution, and these currents be directed through the independent energizing-coils of a motor, the coils of which are so applied as to produce twelve magnetic poles at all times, the rotation of the two will be synchronous; but if the motor-coils produce but six poles the movable element will be rotated twice while the generator rotates once, or if the motor have four poles its rotation will be three times as fast as that of the generator.

我的发明的另一个特征是在我已经设计的用来利用这种类型的发电机和电动机的方案中,由此可以使单个发电机以该发电机自身相同的速度或者全部以不同的速度来运行多个电动机。我通过构造具有比发电机更少磁极的电动机来实现这一点,在这种情况下,它们的速度将大于发电机的速度,由于它们的磁极数量相对较少,所以速度更高。这从一个例子就能理解。假设发电机有两个独立的发电线圈,这些线圈在两个反向磁化的极靴之间旋转,而电动机有励磁线圈,可以在任何给定的时间在一个组件中产生两个磁极,这倾向于建立电动机的一个旋转。这样构造的发电机通过每次旋转产生四个脉冲或四个电流反转,在发电机的每个独立电路中各有两个,我已经证明了它们对电动机的影响,比如提到过的是移动磁极旋转三百六十度。很明显,如果发电机每转半周可以产生四次相同顺序的反转,那么电动机将会使发电机转两圈。这很容易通过给发电机增加两个换向极或以上述任何其它等效方式改变它来实现。同样的规则也适用于具有多极的发电机和电动机。例如,如果一个发电机由两个电路构成,每个电路产生十二次电流反转来促成一次旋转,这些电流流过一个电动机的独立励磁线圈,该电动机的线圈被这样应用以至于始终产生十二个磁极,两者的旋转将是同步的;但是,如果电动机线圈产生的只是六极,那么可移动组件将旋转两次,而发电机旋转一次,或者如果电动机具有四个磁极,则其旋转速度将是发电机的三倍。

This features, so far as it is necessary to an understanding of the invention, are illustrated in the accompanying drawings.

就理解本发明所必需的而言,这些特征在附图中展示出。

Figure 1 is a diagrammatic illustration of a generator constructed in accordance with my invention. Fig. 2 is a similar view of a correspondingly-constructed motor. Fig. 3 is a diagram of a generator of modified construction. Fig. 4 is a diagram of a motor of corresponding character. Fig. 5 is a diagram of a system containing a generator and several motors adapted to run at various speeds.

图 1 是根据我的发明构造的发电机的示意图。图 2 是一个相应构造的电动机的一个类似视图。图 3 是改进结构的发电机的示意图。图 4 是相应特征的电动机的示意图。图 5 是包含一个发电机和几个适于以不同速度运行的电动机的系统的示意图。

In Fig. 1, let C represent a cylindrical armature-core wound longitudinally with insulated coils A A, which are connected up in series, the terminals of the series being connected to collecting-rings a a on the shaft G. By means of this shaft the armature is mounted to rotate between the poles of an annular field-magnet D, formed with polar projections wound with coils E, that magnetize the said projections. The coils E are included in the circuit of a generator F, by means of which the field-magnet is energized. If thus constructed, the machine is a well-known form of alternating-current generator. To adapt it to my system, however, I wind on armature C a second set of coils B B intermediate to the first, or, in other words, in such positions that while the coils of one set are in the relative positions to the poles of the field-magnet to produce the maximum current those of the other set will be in the position in which they produce the minimum current. The coils B are connected, also, in series and to two collecting-rings b b, secured generally to the shaft at the opposite end of the armature.

在图 1 中，让 C 代表纵向缠绕有绝缘线圈 A A 的一个圆柱形电枢铁芯，这些线圈串联连接，串联的终端连接到轴 G 上的集电环 a a。借助于该轴，电枢被安装成在环形场磁体 D 的磁极之间旋转，该环形场磁体 D 由缠绕有线圈 E 的极性突起形成，线圈 E 磁化所述突起。线圈 E 被包含在发电机 F 的电路中，场磁体通过这些线圈励磁。如果这样构造，这种机器就是一种众所周知的交流发电机。然而，为了将它适用于我的系统，我在电枢 C 上将第二组线圈 B B 缠绕在第一组线圈中间，或者换句话说，在这样的位置，当一组线圈相对于场磁体磁极的位置可以产生最大电流时，另一组线圈将处于产生最小电流的位置。线圈 B 相互串联并连接到两个集电环 b b 上，集电环 b b 一般被固定在电枢轴的另一端上。

The motor shown in Fig. 2 has an annular field-magnet H, with four pole-pieces wound with coils I. The armature is constructed similarly to that of the generator, but with two sets of two coils in closed circuits to correspond with the reduced number of magnetic poles in the field.

图 2 中所示的电动机具有一个环形场磁体 H，四个极靴缠绕有线圈 I。电枢的构造类似于发电机的电枢，但是在闭合电路中具有两组线圈，每组两个，以对应于磁场中减少的磁极数量。

From the foregoing it is evident that one revolution of the armature of the generator producing eight current impulses in each circuit will produce two revolutions of the motor-armature.

从前面可以明显看出，在每个电路中产生八个电流脉冲的发电机电枢的一次（一圈）旋转将产生电动机电枢的两次旋转。

The application of the principle of this invention is not confined to any particular form of machine. In Figs. 3 and 4 a generator and motor of another well-known type are shown. In Fig. 3, J J are magnets disposed in a circle and wound with coils K, which are in circuit with a generator which supplies the current that maintains the field of force. In the usual construction of these machines the armature-conductor L is carried by a suitable frame, so as to be rotated in face of the magnets J J or between these magnets and another similar set in face of them. The magnets are energized so as to be of alternately-opposite polarity throughout the series, so that as the conductor C is rotated the current impulses combine or are added to one another, those produced by the conductor in any given position being all in the same direction. To adapt such a machine to my system, I add a second set of induced conductors M, in all respects similar to the first, but so placed with reference to it that the currents produced in each will differ by a quarter-phase. With such relations it is evident that as the current

decreases in conductor L it increases in conductor M, and conversely, and that any of the forms of motor invented by me for use in this system may be operated by such generator.

本发明原理的应用不限于任何特定形式的机器。在图 3 和图 4 中，展示了另一种众所周知的类型的发电机和电动机。在图 3 中，JJ 是布置成一个环形的磁体，并且缠绕有线圈 K，线圈 K 与一个发电机处在电路中，发电机提供维持磁力场的电流。在这些机器的通常构造中，电枢导体 L 由一个合适的框架承载，以便面对磁体 JJ 或在这些磁体和面对它们的另一组类似磁体之间旋转。磁体被通电励磁，从而在整个串联系列中具有交替相反的极性，使得当导体 C 旋转时，电流脉冲进行组合或一个脉冲加到另一个脉冲上，由导体在任何给定位置产生的电流脉冲都在相同的方向上。为了使这样的机器适用于我的系统，我添加了第二组感应导体 M，在所有方面都与第一组相似，但相对于它放置的位置使得每个产生的电流将相差四分之一相位。利用这种关系，很明显，当导体 L 中的电流减小时，导体 M 中的电流增大，反之亦然，并且由我发明的用于该系统的任何形式的电动机都可以由这种发电机运行。

Fig. 4 is intended to show a motor corresponding to the machine in Fig. 3. The construction of the motor is identical with that of the generator, and if coupled thereto it will run synchronously therewith. J' J' are the field-magnets, and K' the coils thereon. L' is one of the armature-conductors and M' the other.

图 4 旨在展示对应于图 3 中的机器的电动机。该电动机的结构与发电机的结构相同，如果与发电机连接，它将与发电机同步运转。J' J' 是场磁铁，K' 是其上的线圈。L' 是电枢导体之一，M' 是另一个电枢导体。

Fig. 5 shows in diagram other forms of machine. The generator N in this case is shown as consisting of a stationary ring O, wound with twenty-four coils P P', alternate coils being connected in series in two circuits. Within these ring is a disk or drum Q, with projections Q' wound with energizing-coils included in circuit with a generator R. By driving this disk or cylinder alternating currents are produced in the coils P and P', which are carried off to run the several motors.

图 5 展示了机器的其他形式。在这种情况下，发电机 N 显示为由一个静态环 O 组成，它上面缠绕有二十四个线圈 P P'，交替的线圈串联在两个电路中。在这些环内是一个圆盘或圆鼓 Q，其突出部分 Q' 上缠绕有励磁线圈，励磁线圈被包含在带有发电机 R 的电路中。通过驱动这个圆盘或圆柱，在线圈 P 和 P' 中产生交流电，交流电被取走以运行几个电动机。

The motors are composed of a ring or annular field-magnet S, wound with two sets of energizing-coils T T', and armatures U, having projections U' wound with coils V, all connected in series in a closed circuit or each closed independently on itself.

电动机由缠绕有两组励磁线圈 T T' 的一个环形或环状场磁体 S 和电枢 U 组成，电枢 U 具有缠绕有线圈 V 的突出部分 U'，所有的线圈 V 都串联在一个闭合电路中或者各自独立闭合。

Suppose the twelve generator-coils P are wound alternately in opposite directions, so that any two adjacent coils of the same set tend to produce a free pole in the ring O between them and the twelve coils P' to be similarly wound. A single revolution of the disk or cylinder Q, the twelve polar projections of which are of opposite polarity, will therefore produce twelve current impulses in each of the circuits

W W'. Hence the motor X, which has sixteen coils or eight free poles, will make one and a half turns to the generator's one. The motor Y, with twelve coils or six poles, will rotate with twice the speed of the generator, and the motor Z, with eight coils or four poles, will revolve three times as fast as the generator. These multipolar motors have a peculiarity which may be often utilized to great advantage. For example, in the motor X, Fig. 5, the eight poles may be either alternately opposite or there may be at any given time alternately two like and two opposite poles. This is readily attained by making the proper electrical connections. The effect of such a change, however, would be the same as reducing the number of poles one-half, and thereby doubling the speed of any given motor. In these and other respects it will be seen that the invention involves many important and valuable features.

假设十二个发电机线圈 P 以交替相反的方向缠绕,使得同一组的任何两个相邻线圈倾向于在它们之间的环 O 中产生一个自由磁极,并且十二个线圈 P'被类似地缠绕。圆盘或圆柱的十二个极性突起具有相反的极性,因此圆盘或圆柱 Q 的一次旋转将在每个电路 W W'中产生十二个电流脉冲。因此,发电机转动一圈,具有十六个线圈或八个自由磁极的电动机 X 将转动一圈半。具有十二个线圈或六个磁极的电动机 Y 将以两倍于发电机的速度旋转,而具有八个线圈或四个磁极的电动机 Z 将以三倍于发电机的速度旋转。这些多极电机有一个特性,可以经常利用该特性来获得很大的优势。例如,在图 5 的电动机 X 中,八个磁极既可以交替相反,也在任何给定时间可以交替有两个相同的和两个相反的磁极。这很容易通过正确的电连接来实现。然而,这种改变的效果相当于将磁极数量减半,从而使任何给定电动机的速度加倍。在这些和其他方面,将会看到本发明包括许多重要和有价值的特征。

It is obvious that the electrical transformers described in prior patents to me and which have independent primary currents may be used with the generators herein described.

很明显,在我的在先前专利中描述的具有独立初级电流的电力变压器可以与这里描述的发电机一起使用。

It may be stated with respect to the devices hereinafter set forth that the most perfect and harmonious action of the generators and motors is obtained when the numbers of the poles of each are even and not odd. If this is not the case, there will be a certain unevenness of action which is the less appreciable as the number of poles is greater; but even this may be in a measure corrected by special provisions which it is not here necessary to explain. It also follows, as a matter of course, and from the above it is obvious, that if the number of the poles of the motor be greater than that of the generator the motor will revolve at a slower speed than the generator.

关于下文阐述的装置,可以说当每个发电机和电动机的极数是偶数而不是奇数时,可以获得发电机和电动机的最完美和最和谐的动作。如果不是这种情况,则会出现一定的动作不均匀性,随着极数的增加,这种不均匀性会变得不那么明显;但即使是这种情况,也可以通过特殊措施加以纠正,这里没有必要解释。当然,从上面可以明显看出,如果电动机的极数大于发电机的极数,则电动机将以比发电机更低的速度旋转。

What I claim as my invention is—

我主张我的发明是—

1. The combination, with an alternating-current generator comprising independent armature-circuits formed by conductors alternately disposed, so that the currents developed therein will differ in phase, and field-magnet poles in excess of the number of armature-circuits, of a motor having independent energizing-circuits connected to the armature-circuits of the generator, substantially as set forth.

1、存在一个组合，它包括：一个交流发电机，它包括由交替布置的导体形成的独立电枢电路，使得其中产生的电流在相位上不同，并且具有超过电枢电路数量的励磁磁极；一个电动机，它具有连接到发电机电枢电路的独立励磁电路，如上所述。

2. The combination, with a source of alternating currents which differ in phase and comprising a rotating magneto-electric machine yielding a given number of current impulses or alternations for each turn or revolution, of a motor or motors having independent energizing-circuits through which the said currents are caused to flow, and poles which in number are less than the number of current impulses produced in each motor-circuit by one turn or revolution of the magneto-machine, as set forth.

2、存在一个组合，它包括：一个电流相位不同的交流电源，包括一个旋转的磁电机，每转一周产生一定数量的电流脉冲或交变电流；一个或多个具有独立激励电路的电动机，所述电流流过这些电路，磁极数少于磁电机每转一周在电动机的每个电路中产生的电流脉冲数，如上所述。

3. The combination, with a multipolar alternating-current machine having independent induced or current-generating circuits, of motors having independent energizing-circuits and a smaller number of poles than the generator, as set forth.

3、具有独立感应电路或电流产生电路的多极交流电机与具有独立激励电路和比发电机更少的极数的电动机的组合，如上所述。

4. The combination, with an alternating-current generator having independent induced circuits and constructed or adapted to produce a given number of current impulses or alternations for each turn or revolution, of motors having corresponding energizing-circuits and poles which in number are less than the number of current impulses produced in each circuit in a turn or revolution of the generator, as set forth.

4、一个交流发电机和多个电动机的组合，该发电机具有独立的感应电路，并且被构造或适用于每转产生给定数量的电流脉冲或电流交替，所述电动机具有相应的励磁电路和磁极，其数量少于发电机的每转在每个电路中产生的电流脉冲数量。

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(No Model.)

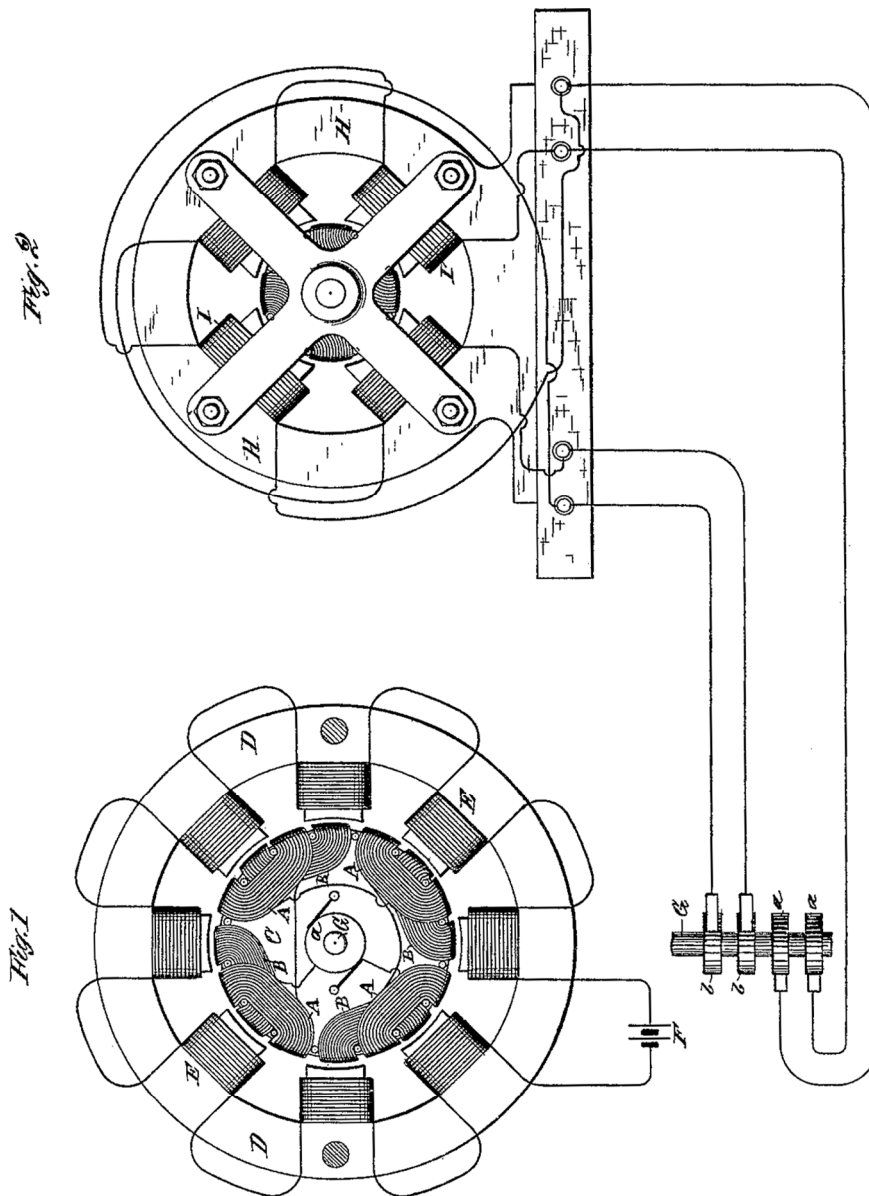
3 Sheets—Sheet 1.

N. TESLA.

SYSTEM OF ELECTRICAL TRANSMISSION OF POWER.

No. 487,796.

Patented Dec. 13, 1892.



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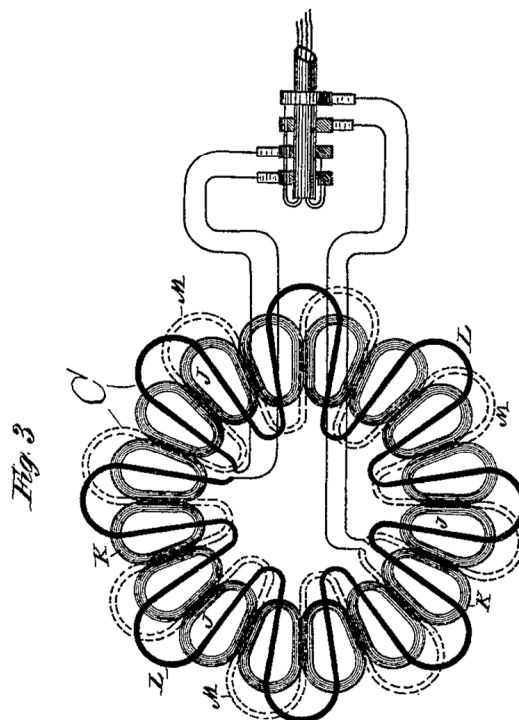
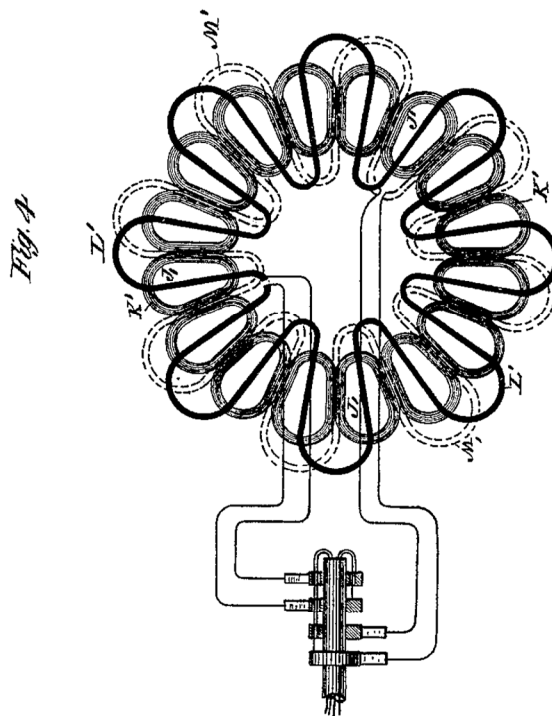
ATTORNEYS.

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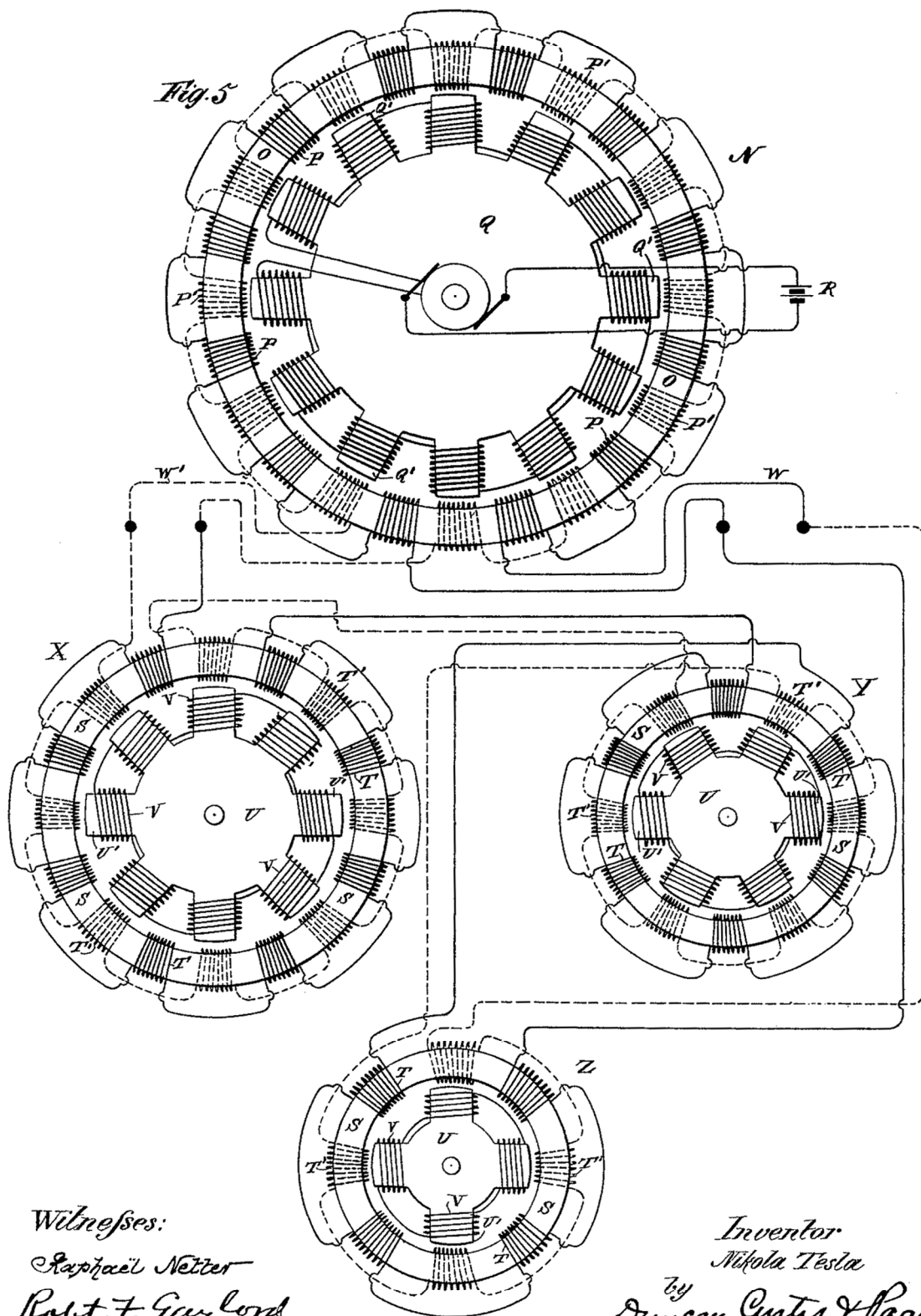
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ELECTRICAL TRANSMISSION OF POWER.

电力传输

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纽约州纽约市的尼古拉·特斯拉将专利转让给纽约市的特斯拉电气公司

SPECIFICATION forming part of Letters Patent No. 511,559, dated December 26, 1893.

Application filed December 8, 1888. Serial No. 293,051. (No model.)

该说明书形成了颁发于 1893 年 12 月 26 日编号为 511,559 的专利证书的一部分。

申请于 1888 年 12 月 8 日提交。序列号为 293,051。(没有模型)

To all whom it may concern:

致所有相关人士:

Be it known that I, NIKOLA TESLA, a subject of the Emperor of Austria-Hungary, from Smiljan, Lika, border country of Austria-Hungary, residing at New York, in the county and State of New York, have invented certain new and useful Improvements in the Electrical Transmission of Power, of which the following is a specification, reference being had to the drawings accompanying and forming a part of the same.

众所周知，我、尼古拉·特斯拉、一位奥匈帝国的臣民，来自奥匈帝国边境地区的利卡县的史密里安村，现在居住在纽约州纽约郡纽约市，在电力传输方面已经发明了某些新的和有用的改进，以下是该发明一个说明书，必须参考随附的图纸，它已形成该说明书的一部分。

In certain patents heretofore granted, I have shown and described a system of electrical power transmission, in which each motor contained two or more independent energizing circuits through which were caused to pass alternating currents, having in each circuit such a difference of phase that by their combined or resultant action they produced a rotary progression of the poles or points of maximum magnetic effect of the motor and thereby maintained the rotation of its movable element.

在迄今为止授予的某些专利中，我已经展示并描述了一种电力传输系统，其中每个电动机包含两个或更多的独立励磁电路，使交流电通过这些电路，在每个电路中具有这样的相位差，即这些交流电通过它们的组合作用或合成作用来产生电动机的磁极或最大磁效应点的一个旋转前进，从而维持其可移动组件的旋转。

In the system referred to and described in said patents, the production or generation of the alternating currents upon the combined or resultant action of which the operation of the system depends, is effected by the employment of an alternating current generator with independent induced circuits which, by reason of the winding or other construction of the generator produced currents differing in phase, and these currents were conveyed directly from the generator to the corresponding motor coils by

independent lines or circuits.

在所述专利中的被提及和描述的系统，系统运行依赖于交流电的组合作用或合成作用，该交流电的生产或产生是通过采用配有独立感应电路的一个交流发电机来实现的。该交流发电机产生不同相位的电流，并且这些电流通过独立的线路或电路从发电机直接传送到相应的电动机线圈。

I have, however, discovered another method of operating these motors, which dispenses with one of the line circuits and enables me to run the motors by means of alternating currents from a single original source.

然而，我发现了另一种运行这些电动机的方法，它免除了线路电路中的一条，使我能够通过交流从一个单一的原始电源来运行电动机。

Broadly stated this invention consists in passing alternating currents, obtained from one original source, through both of the energizing circuits of the motor, and retarding the phases of the current in one circuit to a greater or less extent than in the other.

概括地说，本发明包括通过电动机的两个励磁电路来传送从一个原始电源获得的交流电，并使一个电路中的电流相位比另一个电路中的电流相位或多或少地延迟。

The distribution of current between the two motor circuits may be effected by induction or by derivation. In other words, I may pass the alternating current from the source through one energizing circuit and induce by such current a second current in the other energizing circuit. Or, on the other hand, I may connect up the two energizing circuits of the motor in derivation or multiple arc with the main circuit from the source. In either event I make due provision for maintaining a difference of phase between the currents in the two circuits or branches.

两个电动机电路之间的电流分配可以通过感应或间接连接(通过一个线圈进行连接)来实现。换句话说，我可以使来自电源的交流电通过一个励磁电路，并利用该电流在另一个励磁电路中感应出第二电流。或者，从另一方面来说，我可以把电动机的两个励磁电路从电源处与干线电路进行间接连接或多弧连接。在这两种情况下，我都采取了适当的措施来保持两个电路或支路中的电流之间的一个相位差。

In carrying out my invention I have used various means for securing this result. For example, when I induce a current in one of the circuits from the current flowing in the other, I employ a form of converter or bring the two circuits into such inductive relations as will produce the necessary difference of phase. Or, when I obtain the two energizing currents by derivation, I make the two circuits of different degrees of self inductance by inserting a resistance or a self induction coil in one of said circuits, or I combine these devices in different ways as I shall more specifically describe hereinafter.

在实施我的发明时，我使用了各种方法来获得这个结果。例如，当我利用一个电路中的电流去感应出另一个电路中的电流时，我采用一种形式的变流器或将两个电路引入能产生必要的相位差的感应关系。或者，当我利用间接连接获得两个励磁电流时，我通过在所述电路之一中插入电阻或自感应线圈来形成两个自感程度不同的电路，或者我以不同的方式组合这些器

件，这将在下文中更具体地描述。

The accompanying drawings to which I now refer in further illustration of my invention, are a series of diagrams illustrating, not the specific construction of the particular devices which I may or may not have used, but rather, the electrical connections and relations to be adopted in carrying out the present system by means of devices which are now well known.

我现在进一步说明我的发明所参考的附图是一系列示意图，这些示意图不是说明我可能使用过或可能没有使用过的特定装置的具体结构，而是说明在通过现在众所周知的装置实现本系统时要采用的电连接和电关系。

Figure 1 is a diagram illustrating the method of operating the motors by inducing one of the energizing currents by the other. Fig. 2 is a similar diagram of the method of operating the motors where the two energizing currents are obtained by derivation from a single source. Fig. 3 is a modified application of this principle.

图 1 是由一个励磁电流感应出另一个励磁电流来操作电动机的方法的示意图。图 2 是运行电动机的方法的类似示意图，该电动机的两个励磁电流是通过间接连接从单个电源获得。图 3 是这一原理的一个修改后的应用。

Referring to Fig. 1 let A represent the source of alternating currents which are to be utilized in operating the motor or motors. It will be understood that considered as a source of current it may be either a primary or secondary generator.

参考图 1，让 A 代表用于运行一个或多个电动机的交流电源。应当理解，作为一个电流源，它可以是主发电机或次发电机。

B B designate the conductors of the circuit which convey the alternating currents to one or more motors. The motor has two energizing circuits or sets of coils C D. One of these circuits as C is connected directly with the circuit B. The other set of coils as D, is connected up in the secondary circuit of an electrical transformer or induction coil T. The primary coil P of this transformer, is included in the circuit B. The alternations of current in the circuit B tend to establish in their passage through the coils C, a polarity at right angles to that set up by the coils D, and if the currents in the two sets of coils accorded in their phases, no rotary effect would be produced. But the secondary current developed in the coil P' of the transformer, will lag behind that in the primary which lag or retardation may be increased as I have shown in another application, to a sufficient extent to practically obtain the same result as though two independent alternating currents were used to energize the motor.

B B 表示将交流电输送到一个或多个电动机的电路导体。电动机有两个励磁电路或两组线圈 C D。这些电路中的一个，如 C，直接与电路 B 相连。另一组线圈 D 连接在一个变压器的次级电路中或感应线圈 T 上。这个变压器的初级线圈 P 被包含在电路 B 中。电路 B 中的电流的交替趋向于在它们通过线圈 C 的过程中建立与线圈 D 建立的极性成直角的极性，并且如果两组线圈中的电流的相位上一致，则不会产生旋转效应。但是在变压器的线圈 P' 中产生的次级电流将滞后于初级电流，正如我在另一个应用中已经展示的，这种滞后或阻滞可以增加足够的程度，实际上获得的结果与使用两个独立的交流电来励磁电动机的结果相同。

In Fig. 2 the two energizing circuits of the motor are shown connected in multiple arc to the circuit B B, and in one of these circuits is a resistance R. Assuming the two motor circuits to have the same self induction and resistance no rotary effect will be produced by the passage through them of an alternating current from the source A. But if one of the motor circuits, as C, be varied or modified by the introduction of a dead resistance R, the self-induction of that circuit or branch is reduced, and the phases of current therein retarded to a correspondingly less extent. The relative degrees of retardation of the phases of the current in the two motor circuits with respect to those of the unretarded current in the circuit B thus produced, will set up a rotation of the motor which may be practically utilized for many purposes.

在图 2 中，电动机的两个励磁电路以多弧形式连接到电路 B B，并且在这些电路之一中有一个电阻 R。假设电动机的两个电路具有相同的自感和电阻，来自电源 A 的交流电在通过它们时不会产生旋转效应。但如果其中一个电动机电路，如 C，通过引入吸收电阻 R 而被改变或修改，该电路或分支的自感被降低，其中电流的相位相应地有一个较小程度的延迟。这样相对于电路 B 中的未被阻滞的电流，因此在电动机的两个电路中产生的电流相位被阻滞的相对程度将建立实际上可用于许多目的电动机的旋转。

In Fig. 3, the arrangement of the parts is similar to that shown in Fig. 2, except that a self-induction coil as S is introduced into one branch or energizing circuit of the motor. The effect of thus increasing the self-induction in one of the circuits is to retard the phases of the current passing therein to a greater extent than in the other circuit, and in this way to secure the necessary difference in phase between the two energizing currents to produce the rotation of the motor.

在图 3 中，部件的布置类似于图 2 中所示的布置，除了一个自感应线圈，如 S，被引入到电动机的一个支路或励磁电路中。因此，在其中一个电路中增加自感的效果是与另一个电路中更大程度地延迟流经那个电路的电流的相位，并且以这种方式确保两个励磁电流之间必要的相位差，以产生电动机的旋转。

In an application filed, of even date herewith, I have shown and described other ways of accomplishing this result, among which may be noted the introduction of a resistance capable of variation in each motor circuit, or the use of a resistance in one circuit and a self-induction coil in the other.

在与本申请同日提交的另一个申请中，我已经展示并描述了实现该结果的其他方式，在这些方式中可以注意到在每个电动机电路中引入可变的电阻，或者在一个电路中使用一个电阻而在另一个电路中使用一个自感线圈。

In the above description I have referred mainly to motors with two energizing circuits, but it is evident that the invention applies equally to those in which there are more than two of such circuits, the adaption of the same being a matter well understood by those skilled in the art.

在上面的描述中，我主要提到了具有两个励磁电路的电动机，但是很明显，本发明同样适用于具有两个以上这种电路的电动机，本领域的技术人员可以很好地理解这些电路的适应性。

I do not claim in this application the specific devices employed by me in carrying out the invention, having made these the subjects of other applications.

我在本申请中没有主张我在实施本发明中采用的特定装置,这些装置已经成为其他申请的主题。

What I claim herein is—

我在这里主张的是—

1. The method of operating motors having independent energizing circuits, as herein set forth, which consists in passing alternating currents through both of the said circuits and retarding the phases of the current in one circuit to a greater or less extent than in the other.

1、如本文所述,运行具有独立激励电路的电动机的方法,在于使交流电流过两个所述电路,并使一个电路中的电流相位比另一个电路中的电流相位或多或少地延迟。

2. The method of operating motors having independent energizing circuits, as herein set forth, which consists in directing an alternating current from a single source through both circuits of the motor and varying or modifying the relative resistance or self-induction of the motor circuits and thereby producing in the currents differences of phase, as set forth.

2、如本文所述,运行具有独立激励电路的电动机的方法,在于将来自单一电源的一个交流电引导通过电动机的两个电路,并改变或修改电动机电路的相对电阻或自感,从而产生电流相位差,如本文所述。

NIKOLA TESLA.

尼古拉·特斯拉

Witnesses:

FRANK E. HARTLEY,

FRANK B. MURPHY.

见证人:

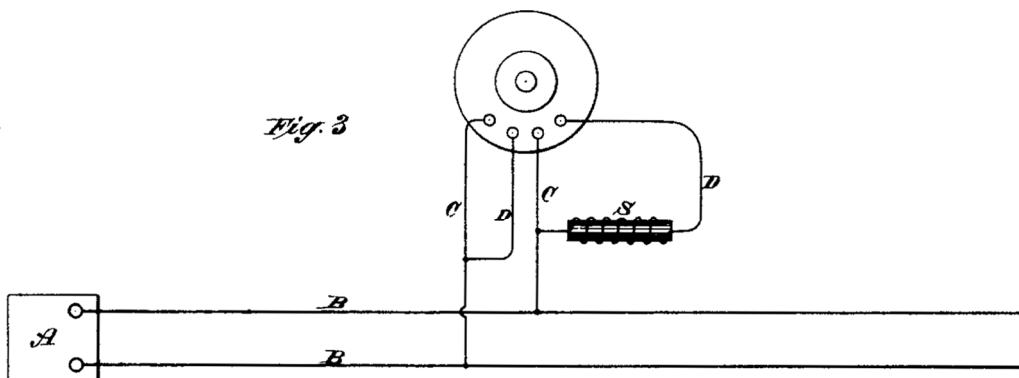
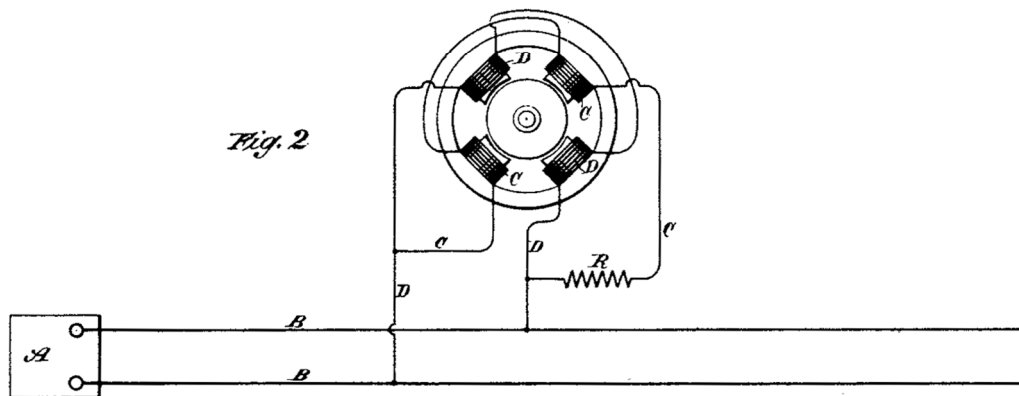
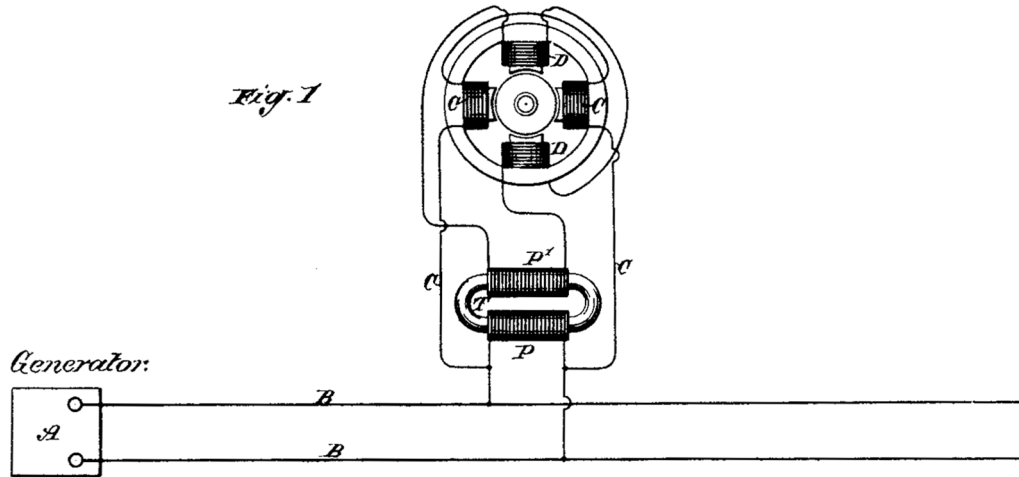
弗兰克·E·哈特利, 弗兰克·B·墨菲。

(No Model.)

N. TESLA.
ELECTRICAL TRANSMISSION OF POWER.

No. 511,559.

Patented Dec. 26, 1893.



WITNESSES:

Raphael Netter
Ernest Hopkinson

INVENTOR

Nikola Tesla

BY

Duncan, Carter & Page
ATTORNEYS.

SYSTEM OF ELECTRICAL POWER TRANSMISSION.

电力传输系统

NIKOLA TESLA, OF NEW YORK, N. Y., ASSIGNOR TO THE TESLA ELECTRIC
COMPANY, OF SAME PLACE.

纽约州纽约市的尼古拉·特斯拉将专利转让给纽约市的特斯拉电气公司

SPECIFICATION forming part of Letters Patent No. 511,560, dated December 26, 1893.

Application filed December 8, 1888. Serial No. 293,052. (No model.)

该说明书形成了颁发于 1893 年 12 月 26 日编号为 511,560 的专利证书的一部分。

申请于 1888 年 12 月 8 日提交。序列号为 293,052。(没有模型)

To all whom it may concern:

致所有相关人士:

Be it known that I, NIKOLA TESLA, a subject of the Emperor of Austria-Hungary, from Smiljan, Lika, border country of Austria-Hungary, residing at New York, in the county and State of New York, have invented certain new and useful Improvements in Systems of Electrical Power Transmission, of which the following is a specification, reference being had to the drawings accompanying and forming a part of the same.

众所周知，我、尼古拉·特斯拉、一位奥匈帝国的臣民，来自奥匈帝国边境地区的利卡县的史密里安村，也是纽约州纽约郡纽约市的一位居民，在电力传输系统方面已经发明了某种新的和有用的改进，以下是该发明一个说明书，必须参考随附的图纸，它已形成该说明书的一部分。

In certain patents heretofore granted, I have shown and described a system of electrical power transmission in which each motor contained two or more independent energizing circuits through which were caused to pass alternating currents having in each circuit such difference of phase that by their combined or resultant action they produced a rotary progression of the poles or points of maximum magnetic effect of the motor and thereby maintained the rotation of its movable element. In the system referred to and described in the said patents the production or generation of the alternating currents, upon the combined or resultant effect of which the operation of the system depends, is effected by the employment of an alternating current generator with independent induced circuits which, by reason of the winding or other construction of the generator, produces currents differing in phase, and these currents are conveyed directly from the generator to the corresponding motor coils by independent lines or circuits. I have, however, discovered that I may produce the same or a similar result by an alternating current from a single original source using between the generator and motors but one line or transmission circuit. Broadly stated, this system or method involves a source of alternating or equivalent currents, a single transmission circuit, a motor having independent energizing

circuits connected with or adapted for connection with the transmission circuit, means for rendering the magnetic effects due to the energizing circuits of different phase, and an armature within the influence of the energizing circuits; the means for accomplishing this result being of such a nature as to retard the current in one energizing circuit to a greater or less extent than in the other. The distribution of the main original current through the two motor circuits may be effected by induction or by derivation. In other words, I may pass the alternating current from the source through one energizing circuit, and induce by such current a second current in the other energizing circuit. Or, on the other hand, I may connect up the two energizing circuits of the motor in derivation or multiple arc with the main circuit from the source. In either event I make due provision for maintaining a difference of phase between the currents in the two circuits or branches.

在迄今为止授予的某些专利中，我已经展示出并描述了一种电力传输系统，其中的每个电动机包含两个或更多个独立的励磁电路，交流电经过这些电路，在每个电路中，交流电具有的相位差能够使得这些交流电的组合作用或合成作用产生电动机的磁极或最大磁效应点的旋转前进，从而维持其可移动组件的旋转。在所述专利中提及和描述的系统，交流电的产生或生成是通过使用具有独立感应电路的交流发电机来实现的，该系统的运行依赖于该交流电的组合作用或合成作用，由于该发电机的绕制或其他构造方式，该发电机的独立感应电路产生相位上不同的电流，这些电流由独立的线路或电路从发电机被直接输送到电动机的相应线圈上。然而，我已经发现，我可以利用来自一个单一原始电源的一个交流电来产生相同或类似的结果，该原始电源在发电机和多个电动机之间使用，且只用一条线路或一个传输电路。概括地说，该系统或方法包括交流电或等效电流的一个来源、单个传输电路、一个电动机，它具有与传输电路连接或适于与传输电路连接的独立励磁电路、由于不同相位的励磁电路而用于呈现磁效应的装置、以及在励磁电路影响范围内的一个电枢；用于实现这一结果的装置具有这样的性质，即在一个励磁电路中比在另一个励磁电路中更大或更小程度地延迟电流。流经两个电动机电路的主原始电流的分配可以通过感应或间接连接（通过线圈连接）来实现。换句话说，我可以使来自电源的交流电通过一个励磁电路，并且利用这样的电流在另一个励磁电路中感应出第二个电流。或者，从另一方面来说，我可以把电动机的两个励磁电路用间接连接或多弧连接从电源位置与主电路相连。在这两种情况下，我都采取了适当的措施来维持两个电路或支路中的电流之间的相位差。

In an application filed by me May 15, 1888, Serial No. 273,993, I have shown and described the means which I have employed for securing this result by inducing one energizing current from the other.

在我于 1888 年 5 月 15 日提交的序列号为 273,993 的申请中，我已经展示并描述了我采用的由一个励磁电流感应另一个励磁电流来获得这一结果的方法。

My present application relates to the means employed when the two energizing currents are obtained from a single original source by derivation.

我的本申请涉及当使用间接连接从单个原始电源获得两个励磁电流时所采用的措施。

In explanation of what appears to be the principle of the operation of my invention and of the functions of the several instrumentalities comprised thereby, let it be assumed that the two energizing circuits of an alternating current motor, such, for example, as I have described in my Patent No. 382,280, dated May 1, 1888, are connected up in derivation or multiple arc with the conductors of a circuit including

an alternating current generator. It is obvious that if both circuits are alike and offer the same resistance to the passage of the current no rotary effect will be produced, for although the periods of the currents in both circuits will lag or be retarded to a certain extent with respect to an unretarded current from the main circuit, their phases will coincide. If, however, the coils of one circuit have a greater number of convolutions around the cores, or a self induction coil be included in one of the circuits, the phases of the current in that circuit are retarded by the increased self induction. The degree of retardation may readily be secured by these means which will produce the difference in electrical phase between the two currents necessary for the practical operation of the motor. If in lieu of increasing the self induction of one circuit a dead resistance be inserted, the self induction of such circuit exerts a correspondingly diminished effect, and the phases of the current flowing in that branch are brought more nearly in unison with those of an unretarded current from the main line and the necessary difference of phase between the currents in the two energizing circuits thus secured. I take advantage of these results in several ways. For example, I may insert variable resistances in both branches or energizing circuits and by varying one or the other so as to bring the phases of the two currents more or less in unison with those of the unretarded current, I may thus vary the direction of the rotation of the motor. In lieu of resistances I may employ variable self induction coils, in both circuits. Or I may use a resistance in one and a self induction coil in the other and vary either or both. This system or means of operating the motors is rendered of great practical value by employing an armature wound with energizing coils closed upon themselves, in which currents are induced by the alternating currents passing in the field coils that serve to greatly increase the mutual attractive effect between the armature and the field magnets. This use of the armature with closed coils I regard as an important feature of my invention. These several features of the invention I shall now describe more in detail by reference to the accompanying drawings.

在解释我的发明的运行原理和其中包括的几个工具的功能时,假设一个交流电动机的两个励磁电路,例如,如同我在 1888 年 5 月 1 日被授予的第 382,280 号专利中描述的,与包含一个交流发电机的电路的导体进行间接连接或多弧连接。很明显,如果两个电路是相似的,并且对电流的流过提供相同的电阻,则不会产生旋转效应,因为尽管两个电路中的电流的周期相对于来自主电路的未被延迟的电流将会延迟或被阻滞到一定程度,但是它们的相位将会在时间上重合。然而,如果一个电路的线圈在铁芯周围具有更多数量的匝数,或者一个电路中包含一个自感线圈,则该电路中电流的相位会由于增加的自感而被延迟。延迟的程度可以容易地通过这些装置来确保,这些装置将产生电动机实际运行所需的两个电流之间的电相位差。如果不是增加一个电路的自感,而是插入一个吸收电阻,则该电路的自感会产生一个相应的减小的效果,并且在该支路中流动的电流的相位与来自干线的未被阻滞的电流的相位更接近一致,从而保证了两个励磁电路中的电流之间的必要相位差。我以几种方式利用这些结果。例如,我可以在两个分支或励磁电路中插入可变电阻,并通过改变其中一个或另一个可变电阻来使两个电流的相位或多或少地与未被延迟的电流的相位一致,因此我可以改变电动机的旋转方向。我可以在两个电路中使用可变自感应线圈来代替电阻。或者,我可以在一个电路中使用一个电阻,在另一个电路中使用一个自感应线圈,并改变其中之一或两者。通过采用被缠绕有自身闭合的励磁线圈的电枢而给运行电动机的这种系统或措施带来了很大的实用价值,其中电流是利用励磁线圈的交流电流感应产生的,这大大增加了电枢和场磁体之间的相互吸引作用。我认为使用这种具有闭合线圈的电枢是我的发明的一个重要特征。现在将参照附图更详细地描述本发明的这几个特征。

Figure 1 is a diagram of the system in which the motor coils or energizing circuits are in derivation to the main line with a dead resistance inserted in one circuit. Fig. 2 is a diagram showing dead resistances

in both motor circuits. Fig. 3 is a diagram showing a self induction coil in one motor circuit. Fig. 4 is a diagram showing a dead resistance in one circuit and a self induction coil in the other. Fig. 5 in like manner shows a self induction coil in each motor circuit. Fig. 6 is a diagram showing the two motor circuits of different electrical character. Fig. 7 is a diagram illustrating means for varying at will the electrical character of the motor circuits.

图 1 是这个系统的示意图，其中电动机线圈或励磁电路间接连接到干线，在一个电路中插入一个吸收电阻。图 2 是展示在电动机的两个电路中的吸收电阻的示意图。图 3 是展示在电动机的一个电路中的一个自感应线圈的示意图。图 4 是展示在一个电路中的一个吸收电阻和在另一个电路中的一个自感应线圈的示意图。图 5 以类似的方式展示了在每个电动机电路中的自感应线圈。图 6 是展示不同电气特性的两个电动机电路的示意图。图 7 是展示用于随意改变电动机电路的电特性的装置的示意图。

Referring to Fig. 1, A designates a suitable source of alternating currents and B B the line wires running therefrom. It will be understood that the generator A may be a primary or secondary generator, and the line B B may be the main transmission circuit or a local circuit from a transformer connected at any point in the line of a main or transmission circuit. For convenience in this case, it will be considered as a line from a given source of current to one or more motors. The motor contains a given number of pole pieces wound with two sets of coils C and D. The armature is wound with permanently closed energizing coils E in which currents are developed by inductive action when the motor is in operation which magnetize the armature core and greatly increase the efficiency of the motor. Assuming the two motor circuits to have the same degree of self induction and resistance no rotary effect will be produced by the passage through them of an alternating current from the source A. But if in one of the motor circuits, as D, a dead resistance represented by R be introduced, the self induction of that circuit or branch is reduced and the phases of current therein retarded to a correspondingly less extent. The relative degrees of retardation of the phases of the current in the two motor circuits with respect to those of an unretarded current from the circuit B thus produced will set up a rotation of the motor which may be practically utilized for many purposes.

参考图 1，A 表示一个合适的交流电源，B B 表示从该电源引出的线路。应当理解，发电机 A 可以是一个主发电机或一个次发电机，线路 B B 可以是主传输电路或来自一个变压器的局部电路，该电路连接在一个主电路中的或者传输电路中的线路上的任何一点上。为了方便起见，在这种情况下，它将被认为是从一个给定的电流源到一个或多个电动机的线路。电动机包含给定数量的极靴，用两组线圈 C 和 D 缠绕。电枢上缠绕有永久闭合的励磁线圈 E，当电动机运行时，在线圈 E 中通过感应作用产生电流，从而磁化电枢铁芯并大大提高电动机的效率。假设两个电动机电路具有相同程度的自感应和电阻，来自电源 A 的交流电流过它们时不会产生旋转效应。但是，如果在电动机的其中一个电路中，如 D，引入由 R 表示的吸收电阻，则该电路或支路的自感降低，并且其中电流的相位的被阻滞程度相对更小。因此在电动机的两个电路中产生相对于来自电路 B 中的未被延迟电流的相位相对延迟度数，该延迟度数将建立电动机的旋转，这实际上可以用于许多目的。

If, as in Fig. 2, a dead resistance R, R' be introduced into each motor circuit, no rotary effect will be produced as long as the resistances are equal, but by varying the resistance in one circuit the retardation of the current in that circuit will be varied, and corresponding effects produced. For example, a reduction of the resistance in one circuit imparts to the motor rotation in one direction while a reduction

of the resistance in the other circuit will produce a rotation in the opposite direction. By means of the two resistances, therefore, capable of variation or of being bodily withdrawn from or inserted in the circuits by any well known means, a perfect regulation of the motors is secured.

如图 2 所示，如果在每个电动机电路中引入一个吸收电阻 R 、 R' ，只要电阻相等，就不会产生旋转效应，但是通过改变一个电路中的电阻，该电路中的电流延迟就会改变，并产生相应的效应。例如，在一个电路中电阻的减小使电动机向一个方向旋转，而在另一个电路中电阻的减小将产生相反方向的旋转。因此，通过两个电阻来确保电动机的完美调节，这两个电阻能够变化或者能够通过任何众所周知的方式整体地从电路中抽出或插入电路中。

In Fig. 3 the arrangement of all the parts is similar to that shown in Fig. 1 except that a self induction coil as S is introduced into one branch or energizing circuit of the motor. The effect of thus increasing the self induction in one of the circuits is to retard the phases of the current passing therein to a greater extent than in the other circuit and in this way to secure the necessary difference in phase between the two energizing currents to produce the rotation of the motor.

在图 3 中，除了自感应线圈 S 被引入到电动机的一个分支或一个励磁电路中，所有部件的布置类似于图 1 所示的布置。因此，增加其中一个电路中的自感效果是比在另一个电路中更大程度地阻滞通过该电路的电流的相位，并且以这种方式确保两个励磁电流之间必要的相位差，以产生电动机的旋转。

In Fig. 4 a self induction coil S is included in one of the motor circuits and a dead resistance R in the other. The increased self induction in one circuit thus produced acts to increase the difference of phase between the current in such motor circuit and the unretarded current in the main line B . On the other hand, the introduction of the dead resistance in the other motor circuit reduces the retardation and brings the phases of the current therein more closely in accord with those of the unretarded current, thus producing a correspondingly greater difference of phase between the two currents in the energizing circuits C and D .

在图 4 中，一个自感应线圈 S 被包含在电动机的一个电路中，而吸收电阻 R 被包含在电动机的另一个电路中。这样在一个电路中产生的增加的自感增加了该电机电路中的电流和干线 B 中的未被延迟的不同电流之间的相位差。另一方面，在另一个电动机电路中引入吸收电阻减小了延迟，并使其中电流的相位与未被延迟电流的相位更加一致，从而在励磁电路 C 和 D 中的两个电流之间产生一个相对更大的相位差。

In Fig. 5, two self induction coils S , S' are shown, one in each motor or energizing circuit. One of these coils as S' is much smaller than the other and has less self induction or counter electro motive force than the other, so that the phases of current will be retarded to a less extent than in the other. The two self induction coils may be of the same character or size if it is desired to use but one at a time for the purpose of reversing the motor, or if they be constructed in well known ways so that they may be varied.

在图 5 中，展示了两个自感应线圈 S 、 S' ，每个电动机电路或每个励磁电路中各有一个。这些线圈中，如 S' ，一个比另一个小得多，并且具有比另一个更小的自感或反电动势，因此电流相位的延迟程度比另一个更小。如果希望一次仅使用一个线圈来反转电动机，或者如果它们以众所周知的方式被构造得可以改变，则两个自感线圈可以具有相同的特性或尺寸。

In Fig. 7 the usual means for varying the resistance or self-induction of the motor circuits at will are indicated by the lever M sliding over a series of resistance plates, and by a core N which is adapted to be moved in and out of the induction coil S.

在图 7 中，用于随意改变电动机电路的电阻或自感的常用措施，由在一连串电阻板条上滑动的杠杆 M 和适于移入和移出感应线圈 S 的铁芯 N 来表示。

Similar results may be secured by such a construction or organization of the motor as will yield the necessary differences of phase. For example, one set of energizing coils may be of finer wire than the other, or have a greater number of convolutions, or each circuit may contain the same number of convolutions, but composed of different conductors, as, for instance, one of copper, the other of German silver. I have represented this in Fig. 6, in which the coils C are indicated by closer lines than coils D.

通过电动机的这种能产生必要相位差的结构或机制可以随意获得类似的结果。例如，一组励磁线圈可以是比另一组励磁线圈更细的导线，或者具有更多数量的匝圈，或者每个电路可以包含相同数量的匝圈，但是由不同的导体组成，例如一个导体是铜的，另一个是锌白铜的。我已经在图 6 中表示了这一点，其中的线圈 C 用比线圈 D 更紧密的线来表示。

There are other ways of varying the retardation due to the self induction in the two energizing circuits. For example, the motor coils may be all alike, but those of one energizing circuit connected in parallel while the others are connected in series, or the connection in each energizing circuit may be alike, but the currents directed through them may be of different strength, as when one of the currents is supplied from a source of higher electro-motive force.

由于在这两个励磁电路中的自感应，还有其它改变延迟的方法。例如，电动机的线圈可以都是相同，但是一个励磁电路的线圈并联连接，而其他的线圈串联连接，或者每个励磁电路中的连接可以是相同的，但是通过它们的电流可以具有不同的强度，就像当这些电流中的一个是由一个更高电动势的电源提供时一样。

In the above description I have referred mainly to motors with two energizing circuits, but it is evident that the invention applies equally to those in which there are more than two of such circuits, the adaptation of the same being a matter well understood by those skilled in the art.

在上面的描述中，我主要提到了具有两个励磁电路的电动机，但是很明显，本发明同样适用于具有两个以上这种电路的电动机，本领域技术人员可以很好地理解这些电路的适应性。

In using in the claims the term active resistance as applied to the motor circuits in this case, it will be understood that the term refers to the opposing or retarding force existing in the circuits to the passage of the alternating currents. Thus, the two circuits may have the same dead resistance, but different degrees of self induction.

在这种情况下，在主张要求中使用应用于电动机电路的术语“有效电阻”时，可以理解，该术语指的是电路中存在的对交流电通过的对抗或延迟。因此，两个电路可以具有相同的吸收电阻，但自感应程度不同。

What I claim as my invention is—

我主张我的发明是—

1. The combination with a source of alternating currents, and a circuit from the same, of a motor having independent energizing circuits connected with the said circuit, and means for rendering the magnetic effects due to said energizing circuits of different phase and an armature within the influence of said energizing circuits.

1、存在着一个组合，它包括：一个交流电源；来自该电源的一个电路；具有与所述电路连接的励磁电路的一个电动机；由于所述的不同相位的励磁电路和在所述励磁电路影响范围内的一个电枢而用于呈现磁效应的装置。

2. The combination with a source of alternating currents and a circuit from the same, of a motor having independent energizing circuits connected in derivation or multiple arc with the said circuit, the motor or energizing circuits being of different electrical character whereby the alternating currents therein will have a difference of phase, as set forth.

2、存在着一个组合，它包括：一个交流电源和来自该电源的一个电路；一个电动机，具有与所述电路间接连接或多弧连接的励磁电路；该电动机或励磁电路具有不同的电特性，由此，其中的交流电将具有不同的相位差，如上所述。

3. The combination with a source of alternating currents and a circuit from the same, of a motor having independent energizing circuits connected in derivation or multiple arc with the said circuit and of different active resistance, as set forth.

3、存在着一个组合，它包括：一个交流电源和来自该电源的一个电路；一个电动机，具有与所述电路间接连接或多弧连接的励磁电路，这些励磁电路具有不同的有效电阻，如上所述。

4. In an alternating current motor, the combination with field magnets, of independent energizing circuits, adapted to be connected in multiple arc with the conductors of the line or transmission circuit and a resistance or self induction coil in one or both of the said motor circuits, as set forth.

4、在一个交流电动机中，存在着一个组合，它包括：场磁体与独立的励磁电路；这些电路适于以多弧方式与线路或传输电路中的导体以及在电动机的一个或两个所述电路中的一个电阻或自感线圈连接，如上所述。

5. In an alternating current motor, the combination with the field magnets or cores of independent energizing coils adapted to be connected in multiple arc with the line or transmission circuit, and a variable resistance or self induction coil included in one or both of the motor circuits as set forth.

5、在一个交流电动机中，存在着一个组合，它包括：场磁体或独立励磁线圈的铁芯，该独立励磁线圈适于以多弧方式与线路或传输电路连接；被包含在电动机中的一个或两个电路中的可变的电阻或自感线圈，如上所述。

6. In an alternating current motor, the combination with the field magnets or cores and independent energizing circuits of different active resistance and adapted to be connected with the line or transmission circuit, of an armature wound with closed energizing coils or conductors, as set forth.

6、在一个交流电动机中，存在着一个组合，它包括：场磁体或铁芯与独立的励磁电路；这些励磁电路具有不同的有效电阻，并适于与线路或传输电路连接；具有缠绕有闭合的励磁线圈或导体的一个电枢，如上所述。

7. The combination of a generator of alternating currents, a pair of mains connected thereto, a multiple circuit differential phase, and an electric motor having one circuit connected directly to said mains, and the other circuit connected to said mains through an interposed electro-motive phase-changing device adapted to change the time period of the currents passing through it.

7、在一个交流电动机中，存在着一个组合，它包括：一个交流发电机；连接到该发电机的一对干线；一个电动机，它的一个电路连接到所述干线，另一个电路通过插入的电动势换相装置连接到所述干线，该电动势换相装置适于改变流过它的电流的时间周期。

NIKOLA TESLA.

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Witnesses:

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N. TESLA.

SYSTEM OF ELECTRICAL POWER TRANSMISSION.

No. 511,560.

Patented Dec. 26, 1893.

Fig. 1

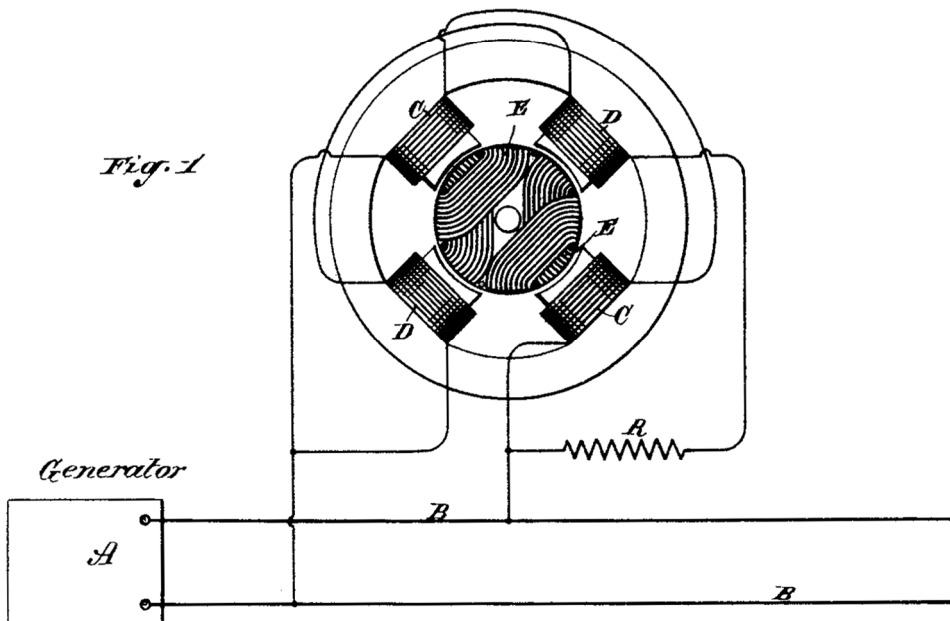
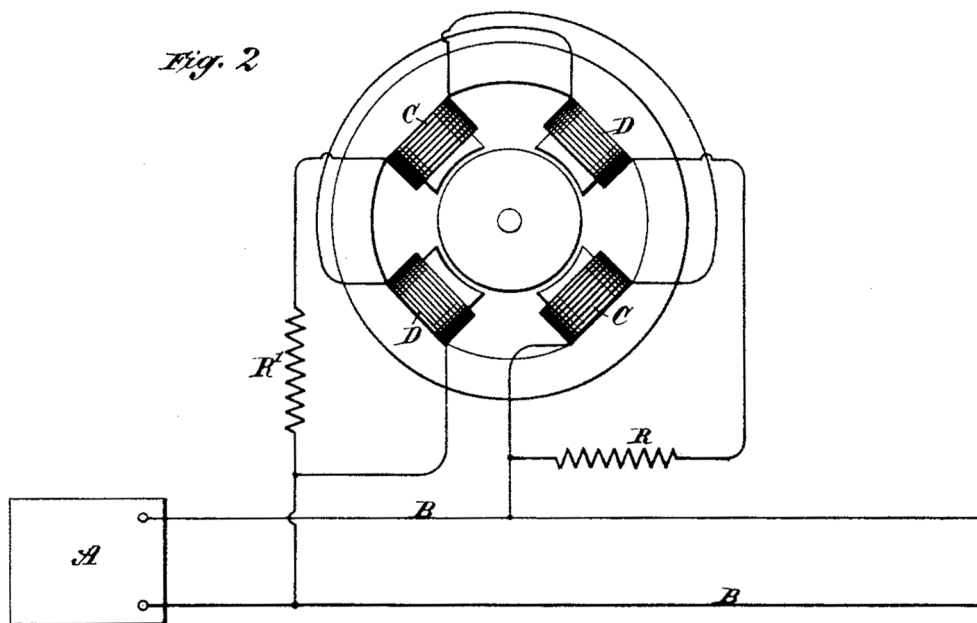


Fig. 2



WITNESSES:

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Ernest Hopkinson

INVENTOR

Nikola Tesla

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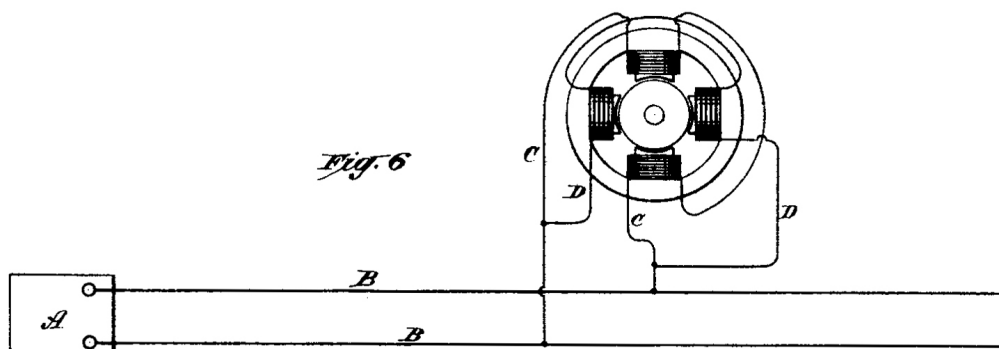
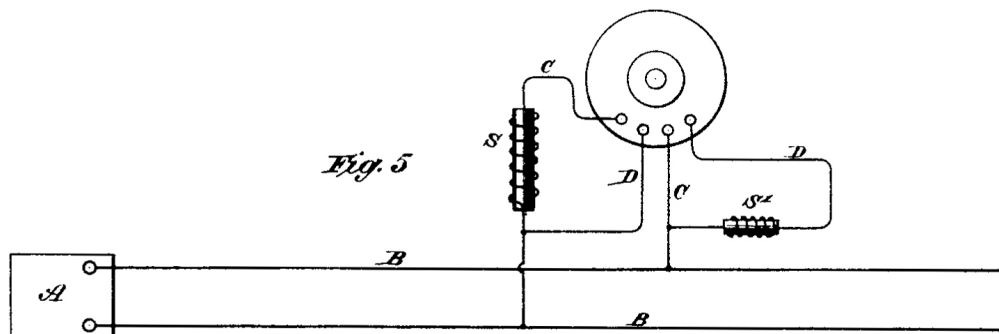
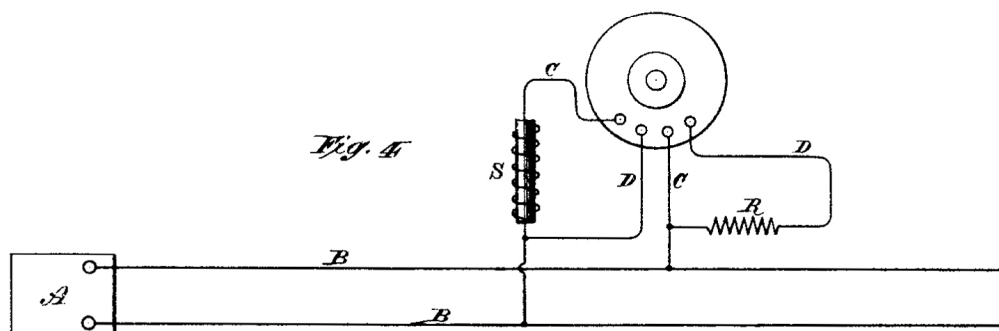
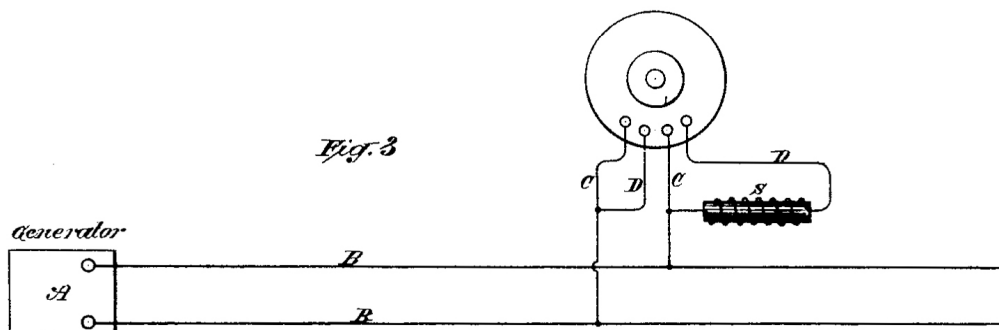
Duncan, Curtis & Page
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SYSTEM OF ELECTRICAL POWER TRANSMISSION.

No. 511,560.

Patented Dec. 26, 1893.



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(No Model.)

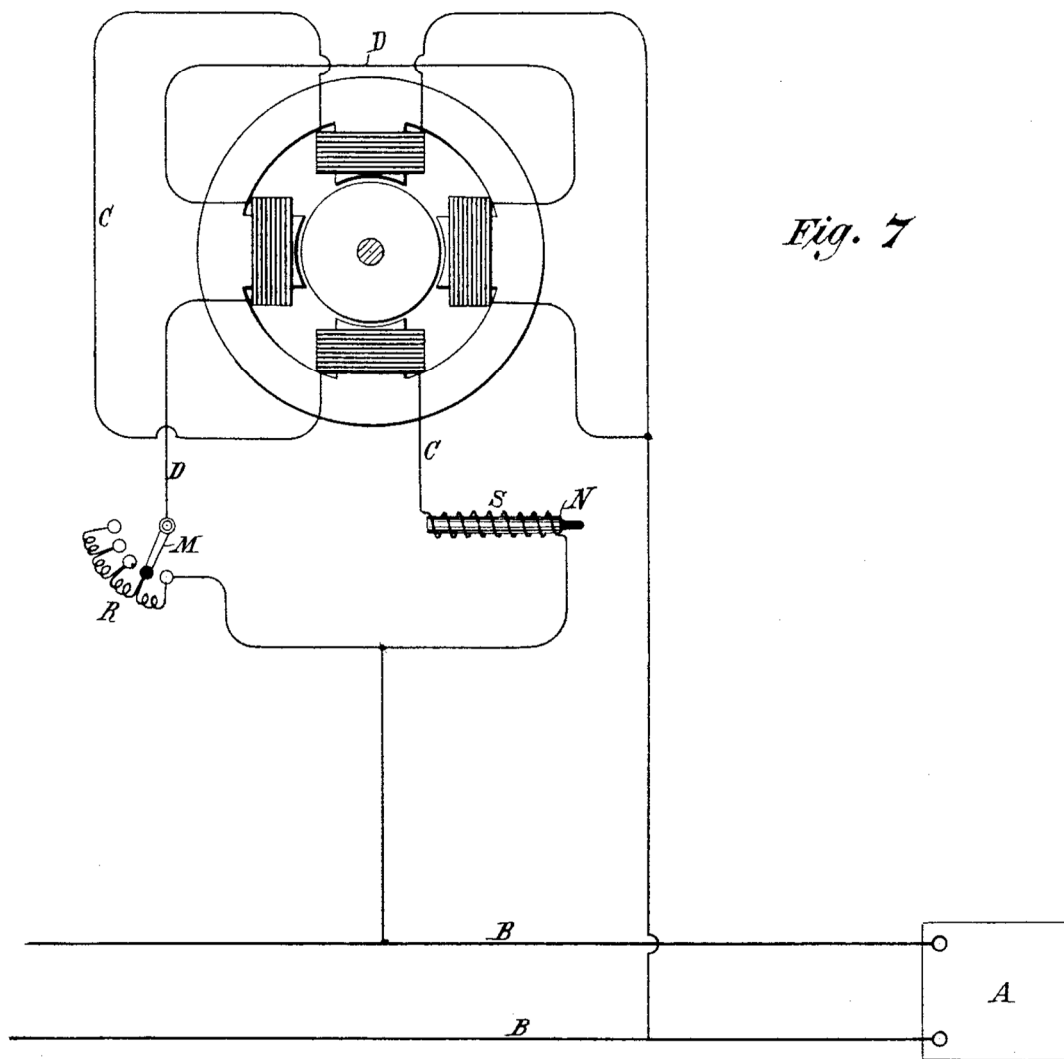
3 Sheets—Sheet 3.

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SYSTEM OF ELECTRICAL POWER TRANSMISSION.

No. 511,560.

Patented Dec. 26, 1893.



WITNESSES

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ELECTRICAL TRANSMISSION OF POWER.

电力传输

NIKOLA TESLA, OF NEW YORK, N. Y., ASSIGNOR TO THE TESLA ELECTRIC
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纽约州纽约市的尼古拉·特斯拉将专利权转让给纽约市的特斯拉电气公司。

SPECIFICATION forming part of Letters Patent No. 511,915 dated January 2, 1894.
Original application filed May 15, 1888, Serial No. 273,993. Divided and this application filed
December 3, 1888, Serial No. 292,475. (No model.)

该说明书形成了颁发于 1894 年 1 月 2 日编号为 511,915 的专利证书的一部分。
原申请于 1888 年 5 月 15 日提交。序列号为 273,993。在 1888 年 12 月 3 日被分立
并提交申请。序列号为 292,475。(没有模型)

To all whom it may concern:

致所有相关人士：

Be it known that I, NIKOLA TESLA, from Smiljan, Lika, border country of Austria-Hungary, a subject of the Emperor of Austria-Hungary, residing at New York, in the county and State of New York, have invented a new and useful Method of Electrical Transmission of Power, of which the following is a description, this application being a division of an application filed by me on May 16, 1888, Serial No. 273,993, and for the method of operating motors contained in such application.

众所周知，我、尼古拉·特斯拉，来自奥匈帝国边境地区的利卡县的史密里安村，是一位奥匈帝国的臣民，现在居住在纽约州纽约郡纽约市，在电力传输方面已经发明了一种新的和有用的方法，以下是该发明一个说明书，本申请是我于 1888 年 5 月 16 日提交的序列号为 273,993 的申请的分立，并涉及该申请中所包含的电动机的运行方法。

In former patents granted to me I have shown and described a system for the electrical transmission of power characterized by the following particulars: The motor contains independent energizing circuits and the generator has corresponding induced or current generating circuits which are connected by independent line circuits with those of the motor. The disposition of the generator coils is such that the currents developed in the circuits including them will have a certain difference of phase, for example, that the maximum periods of the currents generated in one of its circuits coincide with the minimum periods of the currents produced in the other circuit, and the corresponding energizing circuits of the motor are so arranged that the two currents co-operate to effect a progressive shifting of the magnetic poles or the points of maximum magnetic effect in the motor in consequence of which a rotation of its movable element is maintained.

在授予我的以前的专利中，我已经展示并描述了一种电力传输系统，其特征就在于以下细节：电动机包含独立的励磁电路，发电机具有相应的感应电路或电流产生电路，这些电路通过独立的线路电路与电动机的线路电路连接。发电机线圈的布置使得在包含这些线圈的电路中产

生的电流将具有一定的相位差，例如，在这些电路的其中一个电路中，生成的电流的最大值周期与在另一个电路中产生的电流的最小值周期相重合，并且电动机的相应励磁电路被布置成使得两个电流共同作用以实现电动机中磁极或最大磁效应点的渐进转移，由此维持其可移动组件的旋转。

My present invention involves this system of electrical power transmission; its distinguishing characteristic being the mode or method of generating or producing the alternating currents which run or operate the motor.

我的发明涉及这种电力传输系统；其明显特征是产生或生产用来运行或操作电动机的交流电的模式或方法。

This invention is carried out in the following way: Instead of generating directly the alternating currents in each of the circuits which include the energizing coils of the motor, as by means of the induced coils of a magneto electric machine, I generate or produce an alternating current in but one of such circuits directly and by means of such current induce the proper current in the other energizing motor circuit. When the independent currents are both produced in the magneto machine it will be observed that the two line or transmitting circuits will of necessity extend the entire distance from the generator to the motor, but that by the method herein provided, one line circuit may be dispensed with as one circuit or that from the generator may be brought into the proper inductive relation to the other at any desired point.

本发明以如下方式实现：不是像利用一个磁电机的感应线圈那样，在包含了电动机励磁线圈的每个电路中直接产生交流电，我是直接在其中一个电路中产生交流电，并通过该电流在另一个励磁电路中感应出适当的电流。当这两个独立的电流都在磁电机中产生时，可以观察到，两个线路或传输电路必然会从发电机延伸到电动机的整个距离，但是通过这里提供的方法，一个线路电路可以作为一个电路被省去，或者来自发电机的线路可以在任何所需位置与另一个线路形成适当的感应关系。

The following is illustrative of the manner in which I carry out this invention: I employ as a motor, for example, a subdivided annular field magnet within which is mounted a suitable armature, such as a cylinder or disk wound with two coils at right angles, each of which is closed upon itself. On opposite sides of the annular field magnet I wind two coils of insulated wire of a size adapted to carry the current from the generator. Over these coils or close to them in any of the well understood ways I wind secondary coils. I also wind on the annular field magnet midway between the first mentioned coils a pair of coils which I connect up in circuit with the secondary coils. The last pair of coils I make of finer wire than the main or line and secondary coils and with a greater number of convolutions that they may have a greater relative magnetizing and retarding effect than either of the others. By connecting up the main coils in circuit with a generator of alternating currents the armature of the motor will be rotated. It is probable that this action is explained by the following theory: A current impulse on the line passing through the main coils establishes the magnetic poles of the annular field magnets at points midway between said coils. But this impulse produces in the secondary coils a current which, circulating through the second pair of energizing coils tends to establish the poles at points ninety degrees removed from their first position with the result of producing a movement or shifting of the poles in obedience to the combined magnetizing effect of the two sets of coils. This shifting continued by each successive current

impulse establishes what may be termed a rotary effort and operates to maintain the armature in rotation.

以下是我实施本发明的方式的说明：例如，我采用细分的环形励磁磁体作为电动机，在该磁体中安装有一个合适的电枢，例如被缠绕有两个互成直角的线圈的一个圆柱体或圆盘，每个线圈自身闭合。在环形励磁磁体的对侧，我缠绕了两个绝缘导线线圈，其尺寸适于承载来自发电机的电流。在这些线圈上或以任何熟知的方式靠近它们，我缠绕了次级线圈。我还在第一次提到的线圈的不同个体中间的环形励磁磁体上缠绕了一对线圈，我在电路中将这对线圈与次级线圈连接起来。我用比主线或线路和次级线圈更细的导线制成最后这对线圈，并且具有更多数量的匝圈，使得它们可以比其他线圈的任何一个具有更大的相对的磁化和延迟效果。把电路中的主线圈与一个交流发电机连接起来，电动机的电枢就会转动。这种行为可能可以用以下理论来解释：穿过主线圈的线路上有一个电流脉冲在所述的多个线圈之间的中途点建立环形励磁磁体的磁极。但是该脉冲在次级线圈中产生一个电流，该电流通过第二对励磁线圈循环，趋向于将磁极建立在与它们的第一位置相距 90 度的点上，结果产生磁极的移动或转移，以服从两组线圈的组合磁化效果。由每个连续的电流脉冲继续的这种转移建立了所谓的旋转力，并且该转移运行以维持电枢旋转。

In the drawings annexed I have shown in Figure 1 an alternating current generator connected with a motor, shown diagrammatically and constructed in accordance with my invention, and in Fig. 2 a diagram of a modified form of motor.

在附图中，我在图 1 中展示出与一个电动机连接的一个交流发电机，示意性地展示并根据我的发明进行构建，并且在图 2 中展示了一个改进形式的电动机。

A designates any ordinary form of alternating current generator and B B the line wires for connecting the same with the motor.

A 表示任何普通形式的交流发电机，B B 表示连接发电机和电动机的导线。

C is the annular field magnet of the motor.

C 是电动机的环形励磁磁体。

D D are two main coils wound on opposite sides of the ring or annular field and connected up with the line, and having a tendency to magnetize the ring C with opposite poles midway between the two coils.

DD 是两个主线圈，缠绕在环或环形磁场的对侧，并与线路连接，并且具有用两个线圈间中途的相反磁极来磁化环 C 的趋势。

E E are two other magnetizing coils wound midway between coils D D, but having a stronger magnetizing influence for a current of given strength than coils D D.

EE 是缠绕在线圈 DD 间中途的另外两个磁化线圈，但是对于给定强度的电流，它们比线圈 DD 具有更强的磁化影响。

F F are the secondary coils which are associated with the main coils D D. They are in circuits which include the coils E E respectively, the connections being made in such order that currents induced in coils F and circulating in coils E will act in opposition to those in coils D in so far only as the location of the magnetic poles in the ring C is concerned.

F F 是与主线圈 D D 相关联的次级线圈。它们分别位于包含线圈 E E 的电路中，其连接顺序使得线圈 F 中的感应电流和在线圈 E 中循环电流只是在环 C 中的磁极位置上将与线圈 D 中的电流作用相反。

The armature may be of any of the forms used by me in my alternating current system and is shown as wound with two closed coils G H at right angles to each other.

电枢可以是我在我的交流系统中使用的任何形式，并且显示为缠绕有两个彼此成直角的闭合线圈 G H。

In order to prolong the magnetizing effect of the induced currents in producing a shifting of the poles, I have carried the principle of the construction exhibited in Fig. 1 farther, thereby obtaining a stronger and better rotary effect.

为了延长在产生磁极的一个转移时感应电流的磁化效果，我将图 1 中所示的结构原理进行了更深入的研究，从而获得了更强更好的旋转效果。

Referring to Fig. 2, C is an annular field magnet having three pairs or oppositely located sets of polar projections K L M. Upon one pair of these projections, as K, the main energizing coils D are wound. Over these are wound the secondary coils E. On the next polar projections L L are wound the second energizing coils F which are in circuit with coils E. Tertiary induced coils E' are then wound over the coils F and on the remaining polar projections M the third energizing coils F' are wound and connected up in the circuit of the tertiary coils E'. The cylindrical or disk armature core N in this motor has polar projections wound with coils O forming closed circuits. My object in constructing the motor in this way is to effect more perfectly a shifting of the points of maximum magnetic effect. For assuming the operation of the motor to be due to the action above set forth—the first effect of a current impulse in this motor will be to magnetize the pole pieces K K, but the current thereby induced in coils E magnetizes the pole pieces L and the current induced in turn in coils E' magnetizes the pole pieces M. The pole pieces are not magnetized, at least to their full extent, simultaneously by this means, but there is enough of a retardation or delay to produce a rotary effect or influence upon the armature. The application of this principle is not limited to the special forms of motor herein shown, as any of the double circuit alternating current motors invented by me and described in former Letters Patent to me may be adapted to the same purpose. This method or mode of producing the currents in the independent energizing circuits of the motor may be carried out in various ways, and it is not material to the invention broadly considered, what devices be employed in effecting the result, viz: the induction from or by the current from the generator or source, of the current or currents which co-operate therewith in producing the rotation of the motor.

参考图 2，C 是一个环形场磁体，具有三对或径向相对定位的磁极突起 K L M 组。在一对这样的突起上，如 K，缠绕有主激励线圈 D。次级线圈 E 缠绕在这些线圈 D 上。在下一个极

性突起 LL 上缠绕第二组励磁线圈 F，线圈 F 与线圈 E 在电路中连接。然后，第三对感应线圈 E' 缠绕在线圈 F 上，第三对励磁线圈 F' 缠绕在剩余的极突起 M 上，并与第三对感应线圈 E' 电路连接。该电动机中的圆柱形或盘形电枢磁芯 N 具有极性突起，缠绕有线圈 O，线圈 O 形成闭合电路。我以这种方式构造电动机的目的是更完美地实现最大磁效应点的转移。假设电动机的运行是由于上述作用——该电动机中一个电流脉冲的第一效应是磁化极片 K K，但因此在线圈 E 中感应出的电流磁化极靴 L，而因此在线圈 E' 中感应出的电流又磁化极靴 M。通过这种方式，极靴不会被同时磁化，至少不会被完全磁化，但是有足够的延迟或延时来对电枢产生旋转的效应或影响。这一原理的应用并不局限于这里所示的特定形式的电动机，因为由我发明并在我以前的专利证书中描述的任何双电路交流电动机都可以适用于相同的目的。在电动机的独立励磁电路中产生电流的这种方法或模式可以以各种方式来实现，并且在广泛考虑的情况下，采用什么装置来实现该结果对本发明并不重要，即：来自发电机或电源的电流产生的感应，该电流或这些电流共同产生电动机的旋转。

I would state that in using the word generator, I mean either a primary generator, such as a magneto machine, or a secondary generator, such as an electrical converter, and in claiming protection for inducing the current in one set of energizing coils by the current which circulates in another, I would be understood as including the induction of the secondary current from the current from the same source as that which traverses the motor coils whether it be flowing in the same branch or part of the circuit or not.

我要说明的是，在使用发电机这个词时，我指的是一个初级发电机，例如一个磁电机，或者一个次级发电机，例如一个电转换器，并且所主张的在由一组线圈中循环的电流在另一组线圈中产生感应电流的过程中，我将被理解该主张包括了次级电流的感应，该次级电流来自同一个电源的电流，无论它是否在电路的相同分支或部分中流动。

What I claim is—

我主张的是—

1. The method of operating electro-magnetic motors having independent energizing circuits, as herein described, which consists in passing an alternating current through one of the energizing circuits and inducing by such current the current in the other energizing circuit of the motor, as set forth.

1、如本文所述，运行具有独立励磁电路的电磁电动机的方法，包括使一个交流电通过一个励磁电路，并由该电流在电动机的另一个励磁电路中感应出电流，如前所述。

2. The method of operating electro-magnetic motors having independent energizing circuits as herein described, which consists in developing an alternating current in one of said energizing circuits and inducing thereby currents in the other energizing circuit or circuits, as herein set forth.

2、如本文所述，运行具有独立励磁电路的电磁电动机的方法，包括在一个所述励磁电路中产生一个交流电，从而在另一个或其他的励磁电路中感应出电流，如前所述。

NIKOLA TESLA.

尼古拉·特斯拉

Witnesses:

GEO. N. MONRO,

EDWARD T. EVANS.

见证人：

杰奥·N·门罗、爱德华·T·埃文斯。

(No Model.)

N. TESLA.
ELECTRICAL TRANSMISSION OF POWER.
No. 511,915. Patented Jan. 2, 1894.

Fig. 1

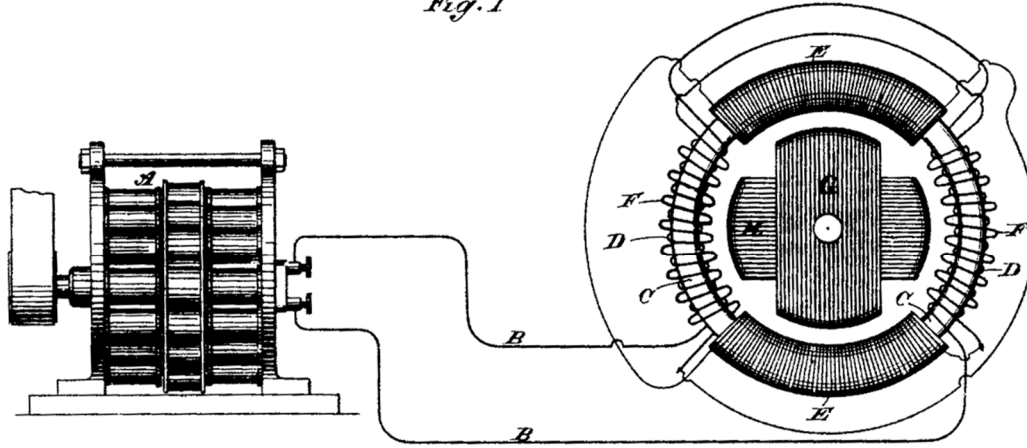
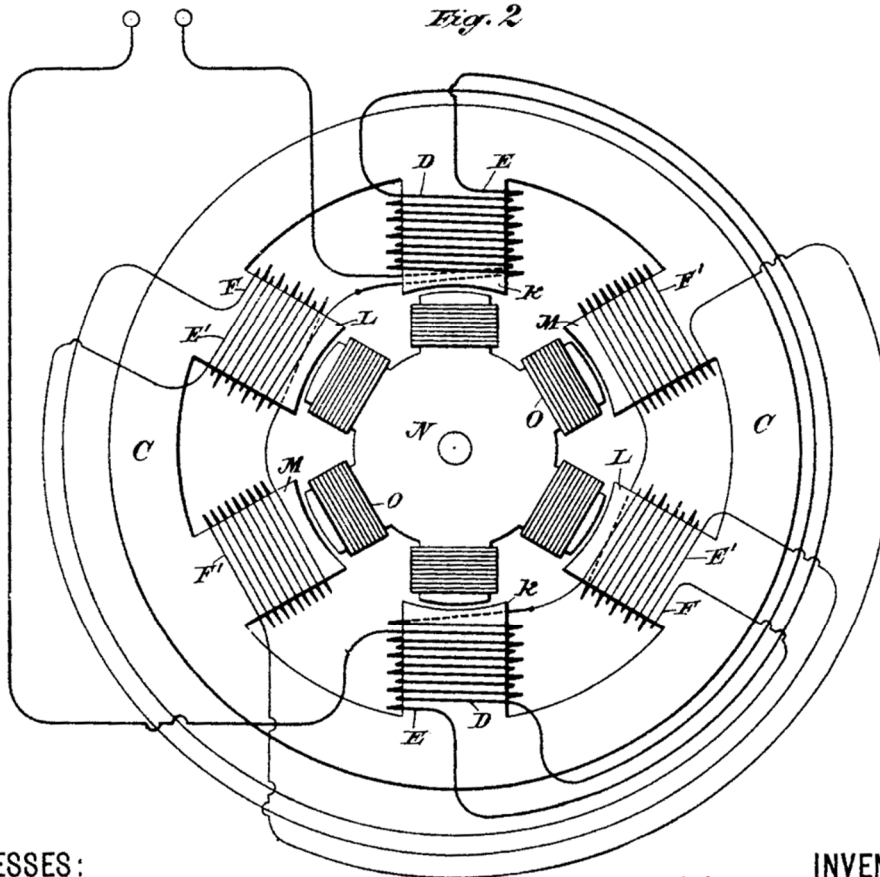


Fig. 2



WITNESSES:

Raphael Netter
H. F. Newbury

INVENTOR

Nikola Tesla
BY
Duncan, Curtis & Page
ATTORNEYS.

ELECTROMAGNETIC MOTOR.

电磁电动机

NIKOLA TESLA, OF NEW YORK, N. Y., ASSIGNOR TO THE TESLA ELECTRIC
COMPANY, OF SAME PLACE.

纽约州纽约市的尼古拉·特斯拉将专利转让给纽约市的特斯拉电气公司

SPECIFICATION forming part of Letters Patent No. 524,426, dated August 14, 1894.

Application filed October 20, 1888. Serial No. 288,677. (No model.)

该说明书形成了颁发于 1894 年 8 月 14 日编号为 524,426 的专利证书的一部分。

申请于 1888 年 10 月 20 日提交。序列号为 288,677。(没有模型)

To all whom it may concern:

致所有相关人士:

Be it known that I, NIKOLA TESLA, a subject of the Emperor of Austria-Hungary, from Smiljan, Lika, border country of Austria-Hungary, and a resident of New York, in the county and State of New York, have invented certain new and useful Improvements in Electromagnetic Motors, of which the following is a specification, reference being had to the drawings accompanying and forming a part of the same.

众所周知，我、尼古拉·特斯拉、一位奥匈帝国的臣民，来自奥匈帝国边境地区的利卡县的史密里安村，现在居住在纽约州纽约郡纽约市，在电磁电动机方面已经发明了某些新的和有用的改进，以下是该发明一个说明书，必须参考随附的图纸，它已经形成了该说明的一部分。

In previous patents of the United States notably in those numbered 381,968 and 382,280, dated May 1, 1888, I have shown and described a system of transmitting power by means of electro-magnetic generators and motors. The distinguishing feature of this system was shown to be the progressive movement or shifting of the magnetic poles or points of maximum attraction of a motor, due to the action or effect of alternating currents passed through independent energizing circuits in the motor. To secure this result the two currents must have different phases, the best results being obtained when the two currents differ by a quarter phase, or in other words when the periods of maximum potential of one current coincide with the minimum periods of the other, and conversely. I have also discovered that a single alternating current may be utilized to produce a progression or shifting of the magnetic poles of a motor if the field magnets of the same be of different magnetic susceptibility in different parts so that the magnetic phases of the same will differ. That is to say, if the field magnets are of such character that their different portions will be differently magnetized—in respect to time—by the same current impulse, and so disposed that the difference of magnetic phase will maintain a rotary or progressive shifting of the points of maximum magnetic effect. This may be accomplished in various ways, as may best be explained by reference to the accompanying drawings, in which—

在以前的美国专利中，特别是在 1888 年 5 月 1 日被授予的编号为 381,968 和 382,280 的专利

中，我已经展示和描述了一种通过电磁发电机和电动机来传输动力的系统。该系统的显著特征是，由于流过电动机中独立的励磁电路的交流电流的作用或影响，电动机的最大吸引的磁极或点产生渐进运动或移动。为了确保这个结果，两个电流必须具有不同的相位，当两个电流相差四分之一相位时，或者换句话说，当一个电流的最大电势周期与另一个电流的最小电势周期重合时，获得最佳结果，反之亦然。我还发现，如果电动机的磁场磁体在不同部分具有不同的磁化率，使得电动机的磁相位不同，则可以利用单个交流电来产生电动机磁极的前进或移动。也就是说，如果场磁体具有这样的特性，即它们的不同部分将被相同的电流脉冲不同地磁化——相对于时间——那么场磁体被这样布置会使得磁相位的差异将保持最大磁效应点的旋转或渐进移动。这可以通过各种方式来实现，参考附图可以更好地解释这一点，其中—

Figure 1, is a diagrammatic view of a motor constructed in accordance with my invention and a generator connected therewith. Fig. 2, is an end view of a modified form of armature for said motor.

图 1 是根据我的发明所构建造的电动机和与其连接的发电机的示意图。图 2 是用于所述电动机的电枢的改进形式的端视图。

Let A designate an ordinary type of alternating current generator in the circuit of which is to be connected a motor or motors, according to my present invention. I construct such motor or motors in the following manner: On a shaft a I mount an armature C, which for convenience of illustration is presumed to be a soft iron plate or disk with two cut-away portions or a bar with rounded ends. Around this armature I place say four poles, D D E E, of soft iron, and, as is usual in all alternating current machines, built up of insulated plates or sections to prevent the heating that would otherwise occur. Each of these cores is surrounded by an energizing coil F and all of these coils are connected to the main circuit from the generator A in series or in any other manner to receive simultaneously the current impulses delivered by the generator. If the cores are all of the same shape or mass, or composition, and the coils are all wound in the same or alternately opposite directions, no rotation would be produced by the passage through the coils of a current, whether alternating or direct, since the attractive forces of the poles upon the soft iron armature would be developed simultaneously and would counterbalance or neutralize each other. But to secure rotation I make, for example, the cores D D short with their coils close to their inner ends and the cores E E long, with their coils removed from the inner ends. By this means I secure a difference in the magnetic phases which the poles exhibit, for while the short cores will respond to the magnetizing effect of an alternation or impulse of current in the coils in a certain time, a greater interval of time will elapse before the same magnetic intensity will be developed at the ends of the longer cores, and in practice I have found that this difference in phase may be utilized to produce the rotation of the armature. The effect being virtually to produce a shifting of the points of maximum magnetic effect similar to that which takes place when two alternating energizing currents, differing in phase are used, as explained in the patents above referred to. The essential difference being that in my patented system the rotation is effected by a time difference of electrical phase, while in the present case it is due to a difference in magnetic phases.

根据本发明，让 A 表示普通类型的交流发电机，在其电路中连接一个或多个电动机。我以下列方式制造这种电动机：在一个轴 a 上安装有电枢 C，为了便于说明，假设电枢 C 是有两个部分被切除的软铁板或圆盘，或者是具有圆形端部的棒或条。在这个电枢周围，我放置了四个软铁磁极 D D E E，和所有交流电动机中常见的一样，由被绝缘的板或被绝缘的分段组

成，以防止会发生的发热。这些铁芯中的每一个都被一个励磁线圈 F 包围，并且所有这些线圈都以串联的方式连接到来自发电机 A 的主电路或者以任何其他方式同时接收由发电机传送的电流脉冲。如果铁芯的形状或质量或成分都是相同的，并且线圈都以相同或交替相反的方向缠绕，则利用通过线圈的电流（无论是交流的还是直流的）都不会产生旋转，因为磁极对软铁电枢的吸引力将同时产生，并相互抵消或中和。但是为了确保旋转，例如，我把铁芯 D D 缩短，线圈靠近内端，把铁芯 E E 加长，线圈远离内端。通过这种方式，我确保了在磁极中表现出的磁相位的差异，因为虽然短铁芯会在一定时间内响应线圈中电流的交替或脉冲的磁化效应，但在较长铁芯的末端会产生相同的磁强度之前将经过更长的时间间隔，实际上我已经发现这种相位差可用于产生电枢的旋转。其效果实际上是产生最大磁效应点的一个转移，类似于当使用两个不同相位的交流励磁电流时发生的转移，如上面引用的专利中所解释的。本质区别在于，在我的专利系统中，旋转是受电相位的一个时间差来实现的，而在本实例中，旋转是由于在磁相位中的一个差异。

The same or similar results are obtainable by other means. For example, to secure the requisite difference of magnetic phase, I may make two of the cores as E E of greater mass than cores D D, whereby their period of saturation will be greater than of cores D D, or I may make the cores E E of hard iron or steel and the cores D D of soft iron, in which case the cores E E offering greater resistance to magnetic changes, will not exhibit their magnetism as soon after the passage of a current as the cores D D. Or if the cores of one set of poles, as D, D, be removed, the attractive force of the coils or solenoids would be exerted instantly while the magnetic cores E E would lag or have a different phase.

通过其他方法也可以获得相同或相似的结果。例如，为了确保磁相位的必要差异，我可以使两个铁芯 E E 的质量大于铁芯 D D 的质量，由此它们的饱和时间将大于铁芯 D D 的饱和时间，或者我可以使铁芯 E E 由硬铁或钢制成，铁芯 D D 由软铁制成，在这种情况下，铁芯 E E 对磁变化提供更大的阻力，不会像铁芯 D D 那样在电流通过后立即表现出磁性。或者，如果一组磁极的磁芯（如 D D）被移除，线圈或螺线管的吸引力将立即发挥作用，而铁芯 E E 将滞后或具有不同的相位。

The special form of the motor is largely a matter of choice, nor is the invention limited to the number of poles nor to the special form of armature shown. For example, I may employ such an armature as that shown in Fig. 2, which is a cylinder or disk C wound with coils G closed upon themselves. This adds materially to the efficiency of the motor for the reason that currents are induced in the closed coils and magnetize the iron cylinder in a manner similar to that described in my Patent No. 383,279 of May 1, 1888.

电动机的特殊形式在很大程度上是一个选择的问题，本发明不限于极数，也不限于所示电枢的特殊形式。例如，我可以使使用如图 2 所示的电枢，它是一个圆柱体或圆盘 C，其上缠绕着线圈 G。因为在闭合线圈和磁化铁柱中感应出电流，这实质上大大增加了电动机的效率，这种方式类似于在 1888 年 5 月 1 日授予我的第 383,279 号专利中的方式。

Without limiting myself, therefore, in the particulars hereinbefore specified, what I claim as my invention is—

因此，在不限制我自己的情况下，在上文指定的细节中，我主张我的发明是—

1. In an alternating current motor the combination with energizing coils adapted to be connected with an external circuit of cores of different magnetic susceptibility so as to exhibit differences of magnetic phase under the influence of an energizing current, as herein set forth.

1、在一个交流电动机中，励磁线圈的组合适于与不同磁化率的铁芯的一个外部电路连接，从而在一个励磁电流的影响下表现出磁相位差，如上所述。

2. The combination in an alternating current motor with a rotary armature of magnetic poles, and coils adapted to be connected with the external circuit surrounding the same, the said cores being constructed of different size or material whereby their magnetic phase will differ in time as set forth.

2、在一个交流电动机中，存在一个组合，它包括：磁极的一个旋转电枢；适于与外部电路连接的线圈，该线圈由该外部电路所围绕；由不同尺寸或材料制成的所述铁芯，因此它们的磁相位将随时间而不同，如上所述。

3. The combination in an electro-magnetic motor with a rotary armature of magnetic cores of different length or mass and energizing coils surrounding the same and adapted to be connected with a single source of alternating currents, as set forth.

3、在一个电磁电动机中，具有不同长度或质量的铁芯的一个旋转电枢以及围绕着铁芯的励磁线圈的组合，该励磁线圈适于与单一交流电源连接，如上所述。

4. The combination in an electro-magnetic motor with a rotary armature of short magnetic cores as D D and long magnetic cores as E E, and energizing coils surrounding the same, those on the cores E E being placed at a distance from the inner ends of the said cores, as herein set forth.

4、在一个电磁电动机中，短铁芯（如 D D）和长铁芯（如 E E）的一个旋转电枢，以及围绕该电枢的励磁线圈的组合，在铁芯 E E 上的线圈被放置在离所述铁芯内端一定距离处，如上所述。

5. The combination in an electro-magnetic motor with energizing coils adapted to be connected with a source of alternating currents and cores of different magnetic susceptibility, of an armature wound with coils closed upon themselves, as herein set forth.

5、在一个电磁电动机中，存在一个组合，它包括：适于与交流电源连接的励磁线圈；不同磁化率的铁芯；以及被缠绕有闭合线圈的一个电枢，如上所述。

6. The combination in an electro-magnetic motor with a rotary armature of field cores of different magnetic susceptibility and energizing coils thereon connected in series and adapted to be connected with a source of alternating currents, as set forth.

6、在一个电磁电动机中，存在一个组合，它包括：具有不同磁化率的励磁铁芯的一个旋转电枢；缠绕在该励磁铁芯上并串联连接的励磁线圈，该励磁线圈适用于与一个交流电源连接，如上所述。

NIKOLA TESLA.

尼古拉·特斯拉

Witnesses:

GEO. N. MONRO,

A. PATTERSON.

见证人:

杰奥·N·门罗、A.帕特森。

(No Model.)

N. TESLA.
ELECTROMAGNETIC MOTOR.

No. 524,426.

Patented Aug. 14, 1894.

Fig. 1

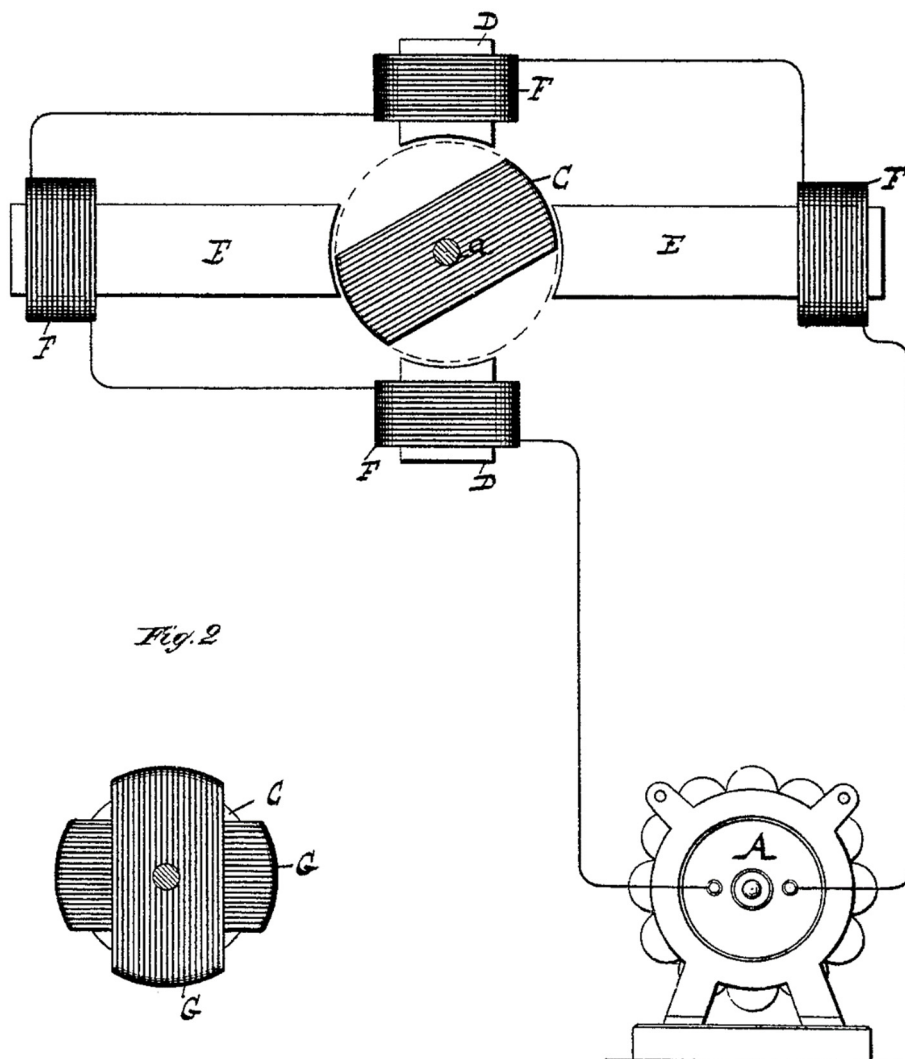
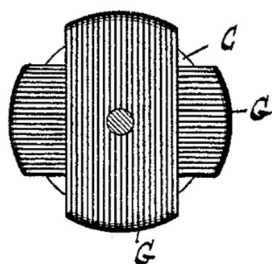


Fig. 2



WITNESSES:

Frank E. Hartley
Frank B. Murphy.

Nikola Tesla INVENTOR
BY
Duncan, Curtis & Page
ATTORNEYS.

ALTERNATING MOTOR.

交流电动机

NIKOLA TESLA, OF NEW YORK, N. Y., ASSIGNOR TO THE TESLA ELECTRIC
COMPANY, OF SAME PLACE.

纽约州纽约市的尼古拉·特斯拉将专利权转让给纽约市的特斯拉电气公司。

SPECIFICATION forming part of Letters Patent No. 555,190, dated February 25, 1896.

Application filed May 15, 1888. Serial No. 273,993. (No model.)

该说明书形成了颁发于 1896 年 2 月 25 日编号为 555,190 的专利证书的一部分。

申请于 1888 年 5 月 15 日提交。序列号为 273,993。(没有模型)

To all whom it may concern:

致所有相关人士：

Be it known that I, NIKOLA TESLA, a citizen of the United States, residing at New York, in the county and State of New York, have invented certain new and useful Improvements in Electromagnetic Motors, of which the following is a specification, reference being had to the drawings accompanying and forming a part of the same.

众所周知，我、尼古拉·特斯拉、一位美国公民，现在居住在纽约州纽约郡纽约市，在电磁电动机方面已经发明了某些新的和有用的改进，以下是该发明一个说明书，必须参考随附的图纸，它已经形成了该说明的一部分。

In former patents granted to me—notably, Patents Nos. 381,968 and 382,280, of May 1, 1888—I have shown and described a system for the electrical transmission of power characterized by the following particulars: The motor contains independent energizing-circuits and the generator has corresponding induced or current-generating circuits which are connected by independent line-circuits with those of the motor, the said circuits being independent in the sense only that the distinctive relations of the currents produced, transmitted and utilized in each are preserved to produce their proper conjoint effect. The disposition of the generator coils or circuits is such that the currents developed therein and transmitted therefrom to the motor will have a certain difference of phase—for example, so that the maximum periods of the currents generated in one of such circuits coincide with the minimum periods of the currents produced in the other circuit, and the corresponding energizing-circuits of the motor are so arranged that the two currents co-operate to effect a progressive shifting of the magnetic poles or the points of maximum magnetic effect in the motor, in consequence of which a rotation of its movable element is maintained.

在以前授予我的专利中，特别是在 1888 年 5 月 1 日的第 381,968 号和第 382,280 号专利，我已经展示和描述了一种电力传输系统，其特征在于以下细节：电动机包含独立的励磁电路，并且发电机具有相应的感应电路或电流产生电路，这些电路通过独立的线路与电动机的电路连接，所述电路的独立仅在于，在每个电路中产生、传输和利用的电流的独特关系被保留，

以产生它们适当的联合效应。发电机的线圈或电路的布置使得在该线圈或电路中产生并从那里传输到电动机的电流将具有一定的相位差，例如，使得在一个这样的电路中产生的电流的最大值周期与在另一个电路中产生的电流的最小值周期一致，并且电动机的相应励磁电路被布置成使得两个电流协作以实现电动机中的磁极或最大磁效应点的渐进转移，其结果是维持其可移动组件的旋转。

My present invention pertains to this system of electrical transmission of power, its novel and distinguishing feature, however, being a special means for generating or producing in the two motor-circuits the alternating current necessary for the operation of the motor, for while in the instances referred to I produce both currents directly by a magneto-electric machine in the present instance I generate or produce in but one of the circuits of the motor directly an alternating current, and by means of such current induce in the other energizing-motor circuit the other alternating current necessary for its operation.

我的发明涉及这种电力传输系统，然而，其新颖和显著的特征是用于在两个电动机电路中产生或产生电动机运行所需的交流电的一个特殊工具，因为在所提及的实例中，我通过一个磁电机直接产生两种电流，而在本实例中，我仅在电动机的一个电路中直接产生或生产交流电，并且利用这种电流在另一个励磁电动机电路中感应出运行该电动机所需的另一种交流电。

When the two currents are both produced in the magneto-electric machine, it will be observed that the two line or transmitting circuits will of necessity extend the entire distance from the generator to the motor; but by the plan herein provided one line-circuit only is required, as the circuit from the generator and the other are brought into inductive relation to each other in the motor itself.

当两个电流都在磁电机中产生时，可以观察到，两个线路或传输电路必然会从发电机延伸到电动机的整个距离；但是根据这里提供的方案，仅需要一个线路电路，因为来自发电机的电路和另一个电路在电动机本身中彼此形成感应关系。

The following is illustrative of a means by which I secure this result in accordance with my present invention: I employ as a motor, for example, a subdivided annular field-magnet within which is mounted a suitable armature, as a cylinder or disk, wound with two coils at right angles, each of which forms a closed circuit. On opposite sides of the annular field-magnet I wind two coils of insulated wire of a size adapted to carry the current from the generator. Over these coils, or close to them, in any of the well-understood ways, I wind secondary coils. I also wind on the annular field-magnet midway between the first-mentioned coils a pair of coils which I connect up in circuit with the secondary coils.

下面是我根据我的专利来说明确保这一结果所用到的一个工具：我将它用作一个电动机，例如，一个细分的环形场磁体，其内部安装一个合适的电枢，该电枢是一个圆柱体或圆盘，上面成直角缠绕两个线圈，每个线圈形成一个闭合电路。在环形场磁体的径向相对侧，我缠绕了两个绝缘导线线圈，其尺寸适于承载来自发电机的电流。在这些线圈上方，或者靠近它们，以任何一种众所周知的方式，我缠绕次级线圈。我还在一开始提到的线圈之间的中途位置的环形场磁体上缠绕了一对线圈，我在电路中将这对线圈与次级线圈连接起来。

The last pair of coils I make of finer wire than the main or line and secondary coils, and with a greater

number of convolutions, that they may have a greater relative magnetizing effect than either of the others.

我制作的最后一对线圈比主线圈或线路和次级线圈更细，并且具有更多的匝数，因此它们可以比其他任何一个都具有相对更大的磁化效果。

By connecting up the main coils in circuit with a generator of alternating currents, the armature of the motor will be rotated. I have assumed that this action is explained by the following theory: A current-impulse on the line passing through the main coils establishes the magnetic poles of the annular field-magnets at points midway between said coils; but this impulse produces in the secondary coils a current differing in phase from the first, which, circulating through the second pair of energizing-coils, tends to establish the pole at points ninety degrees removed from their first position, with the result of producing a movement or shifting of the poles in obedience to the combined magnetizing effect of the two sets of coils. This shifting, continued by each successive current-impulse, establishes what may be termed a “rotary effort,” and operates to maintain the armature in rotation.

把电路中的主线圈与一个交流发电机连接起来，电动机的电枢就会转动。我假设这种行为可以用以下理论来解释：在线路上的流经主线圈的一个电流脉冲在所述线圈之间的中途点建立环形场磁体的磁极；但是该脉冲在次级线圈中产生相位不同于来自主线圈的电流，该电流流经第二对励磁线圈进行循环，趋向于在远离它们的第一位置 90 度的点建立磁极，结果产生服从于两组线圈的组合磁化效果的磁极移动或移位。这种移动，由每个承继的电流脉冲继续，建立了所谓的“旋转力”，并保持电枢旋转。

In the drawings annexed I have shown, in Figure 1, an alternating-current generator connected with a motor shown diagrammatically and constructed in accordance with my invention, and in Fig. 2 a diagram of a modified form of motor.

在附图中，我已经根据我的发明在图 1 中示意性地展示了被构建的与一个电动机连接的一个交流发电机，并且在图 2 中展示了电动机的一个改进形式的示意图。

A designates any ordinary form of alternating-current generator, and B B the line-wires for connecting the same with the motor.

A 表示任何普通形式的交流发电机，B B 表示连接该发电机和电动机的线路导线。

C is the annular field-magnet of the motor.

C 是电动机的环形场磁体。

D D are two main coils wound on opposite sides of the ring or annular field and connected up with the line and having a tendency to magnify the ring C with opposite poles midway between the two coils.

D D 是缠绕在环或环形场的径向相对侧上的两个主线圈，并且与线路连接起来，并且具有放大环 C 的趋势，在两个线圈的中途位置具有相反的磁极。

E E are two other magnetizing-coils wound midway between the coils D D, but having a stronger magnetizing influence for a current of given strength than coils D D.

E E 是缠绕在线圈 D D 中途位置的另外两个磁化线圈，但是对于给定强度的电流，它们比线圈 D D 具有更强的磁化影响。

F F are the secondary coils, which are associated with the main coils D D. They are in circuits which include the coils E E, respectively, the connections being made in such order that currents induced in coils F and circulating in coils E will act in opposition to those in coils E in so far only as the location of the magnetic poles in the ring C is concerned.

F F 是次级线圈，它们与主线圈 D D 相关联。它们分别位于包含线圈 E E 的两个电路中，其连接顺序使得在线圈 F 中感应出的并在线圈 E 中循环的电流的作用方向与线圈 E 中的电流的作用方向相反，这仅仅是就环 C 中磁极的位置而言。

The armature may be of any of the forms used by me in my alternating-current system, and is shown as wound with two closed coils G H at right angles to each other.

电枢可以是在我的交流系统中使用的任何形式，并显示为其上缠绕的两个闭合线圈 G H 彼此成直角。

In order to prolong the magnetizing effect of the induced currents in producing a shifting of the poles, I have carried the principle of the construction exhibited in Fig. 1 further, thereby obtaining a stronger and better rotary effect.

为了在产生磁极转移时延长感应电流的磁化效果，我进一步采用了图 1 所示的构造原理，从而获得更强更好的旋转效果。

Referring to Fig 2, C is an annular field-magnet having three pairs or oppositely-located sets of polar projections K L M. Upon one pair of these projections, as K, the main energizing-coils D are wound. Over these are wound the secondary coils E. On the next polar projections L L are wound the second energizing-coils F, which are in circuit with coils E. Tertiary-induced coils E' are then wound over the coils F, and on the remaining polar projections M the third energizing-coils F' are wound and connected up in the circuit of the tertiary coils E'.

参考图 2，C 是环形场磁体，它具有三对或在径向相对位置上固定的极性突起组 K L M。在其中一对突起上，如 K，缠绕有主激励线圈 D。次级线圈 E 缠绕在这些线圈 D 上。在下一个极性突起 L L 上缠绕第二对励磁线圈 F，它与线圈 E 电路连接。然后，第三对感应线圈 E' 缠绕在线圈 F 上，第三对励磁线圈 F' 缠绕在剩余的极突起 M 上，并与第三对感应线圈 E' 电路连接。

The cylindrical or disk armature core N in this motor has polar projections wound with coils O, forming closed circuits. My object in constructing the motor in this way is to effect more perfectly the shifting of the points of maximum magnetic effect. For, assuming the operation of the motor to be due to the action above set forth, the first effect of a current-impulse in this motor will be to magnetize the pole-

pieces K K; but the current thereby induced in coils E magnetizes the pole-pieces L, and the current induced in turn in coils E' magnetizes the pole-pieces M. The pole-pieces are not magnetized, at least to their full extent, simultaneously by this means; but there is enough of a retardation or delay to produce a rotary effect or influence upon the armature. The application of this principle is not limited to the special forms of motor herein shown, as any of the double-circuit alternating-current motors invented by me and described in former Letters Patent to me may be adapted to the same purpose.

该电动机中的圆柱形或圆盘形电枢铁芯 N 具有缠绕有线圈 O 的极性突起, 线圈 O 形成闭合电路。我以这种方式构造电动机的目的是更完美地实现最大磁效应点的移动。因为, 假设电动机的运行是由于上述作用, 该电动机中的一个电流脉冲的第一个效应将是磁化磁极靴 K K; 但线圈 E 中因此得到的感应电流磁化了极靴 L, 而按顺序线圈 E' 中得到的感应电流又磁化了极靴 M。通过这种方式, 所有的极靴不会被同时磁化, 至少不会被完全磁化; 但是有足够的一个阻滞或延迟来产生对电枢的一个旋转的效应或影响。这一原理的应用并不局限于这里所示的特定形式的电动机, 因为由我发明并在我以前的专利证书中描述的任何双电路交流电动机都可以适用于相同的目的。

This invention, moreover, is not limited to the specific means herein shown for inducing in one energizing-circuit of the motor the currents necessary for co-operating with the primary current of the generator for producing the progressive shifting of the poles or points of maximum magnetic effect.

此外, 本发明不限于这里所示的特定装置, 该装置用于在电动机的一个励磁电路中感应出与发电机的初级电流协同工作所需的电流, 用于产生磁极或最大磁效应点的渐进转移。

I believe that I am the first to produce any kind of motor adapted to be operated by alternating currents and characterized by any arrangement of independent circuits brought into inductive relation so as to produce a rotary effort or effect due to the conjoint action of alternating currents from a source of supply in one of the motor-circuits and alternating currents induced by the first-named currents in the other circuit, and this without reference to the specific character or arrangement of the said two circuits in the motor.

我相信我是第一个能生产具有以下特点的任何类型电动机的人, 这些电动机适合于由交流电运行, 并且其特征在于通过能产生感应关系的独立电路的任何布置, 从而产生一个旋转的力或效果, 这是由于来自电动机电路中的其中一个电路的电源的交流电和在另一个电路中由先前提到的电流感应出的交流电的联合作用, 并且这与电动机中的所述两个电路的具体特征或布置无关。

What I therefore claim as my invention is—

我因此主张我的发明是—

1. In an electromagnetic motor, the combination of independent energizing-circuits, one adapted to be connected with a source of alternating current, the other arranged in inductive relation to the said first circuit whereby the motor will be operated by the resultant action of the two circuits, as set forth.

1、在一个电磁电动机中, 独立的励磁电路的组合, 一个电路适于与交流电源连接, 另一个

被布置成与所述的第一电路成感应关系，由此电动机将由两个电路的合成作用来运行，如上所述。

2. The combination in an electromagnetic motor, with an alternating coil or conductor and a closed-circuit conductor in inductive relation thereto, of an armature mounted so as to be within the field produced by the coil and closed conductor, as set forth.

2、在一个电磁电动机中，存在一个组合，它包括：一个交流线圈或导体，以及与上述线圈成感应关系的一个闭合电路导体；被安装在由该线圈和该闭合导体产生的磁场内的一个电枢，如上所述。

3. The combination in an electromagnetic motor, with energizing-coils adapted to be connected with the generator, of induced coils and independent energizing-coils in circuit therewith and arranged to produce a shifting movement of the points of maximum magnetic effect of the motor, as set forth.

3、在一个电磁电动机中，存在一个组合，它包括：适合于与发电机连接的励磁线圈；在电路中相互连接的感应线圈和独立励磁线圈，并且它们被布置成能产生电动机的最大磁效应的一个转移，如上所述。

4. The combination in an electromagnetic motor of a series of independent energizing-coils or sets of coils and induced coils wound on all the energizing-coils or sets of coils but the last of the series, the first energizing-coil or set of coils being included in circuit with a generator and each succeeding energizing-coil or set of coils being in circuit with the induced coils of the next preceding energizing-coils of the series.

4、在一个电磁电动机中，存在一个组合，它包括：一个串联系列的独立励磁线圈或线圈组；只缠绕在所有励磁线圈或线圈组上的一个串联系列的感应线圈，这是最后一个串联系列；第一个励磁线圈或第一组线圈被包含在具有一个发电机的电路中，并且每一个随后的励磁线圈或每一个随后的线圈组被包含在第一个励磁线圈或第一组线圈的感应线圈的电路中。

5. In a system for electrical transmission of power the combination of an alternating-current generator, a motor with an energizing coil or coils connected with the generator, secondary coils in inductive relation to said energizing-coils, and energizing-coils in circuit therewith arranged in substantially the manner set forth to produce a movement or rotation of the points of maximum magnetic effect of the motor, as set forth.

5、在用于电力传输的一个系统中，存在一个组合，它包括：一个交流发电机；具有与该发电机连接的一个或多个励磁线圈的一个电动机；与所述励磁线圈呈感应关系的次级线圈以及电路中的励磁线圈基本上以所述方式布置，以产生电动机的最大磁效应点的运动或旋转，如上所述。

6. In an electromagnetic motor the combination of independent energizing-circuits, one for connection with a source of alternating currents, the other in inductive relation to the first, whereby a rotary movement or projection of the field-poles will be produced by the conjoint action of the two and an armature mounted within the influence of the field produced by the energizing-circuits and containing

closed coils or circuits, as set forth.

6、在一个电磁电动机中，存在一个组合，它包括：独立的励磁电路，一个与交流电源连接，另一个与第一个电路有感应关系，通过两者的联合作用和被安装在磁场影响范围内的一个电枢来产生场磁极的旋转运动或投射，该磁场是由励磁电路和该电路包含的闭合线圈或闭合电路产生的，如上所述。

NIKOLA TESLA.

尼古拉·特斯拉

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(No Model.)

N. TESLA.
ALTERNATING MOTOR.

No. 555,190.

Patented Feb. 25, 1896.

Fig. 1

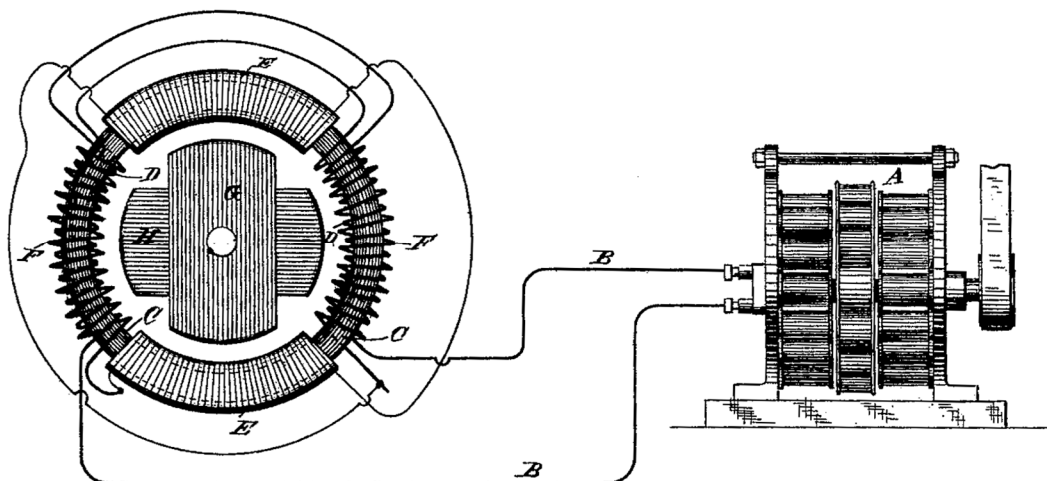
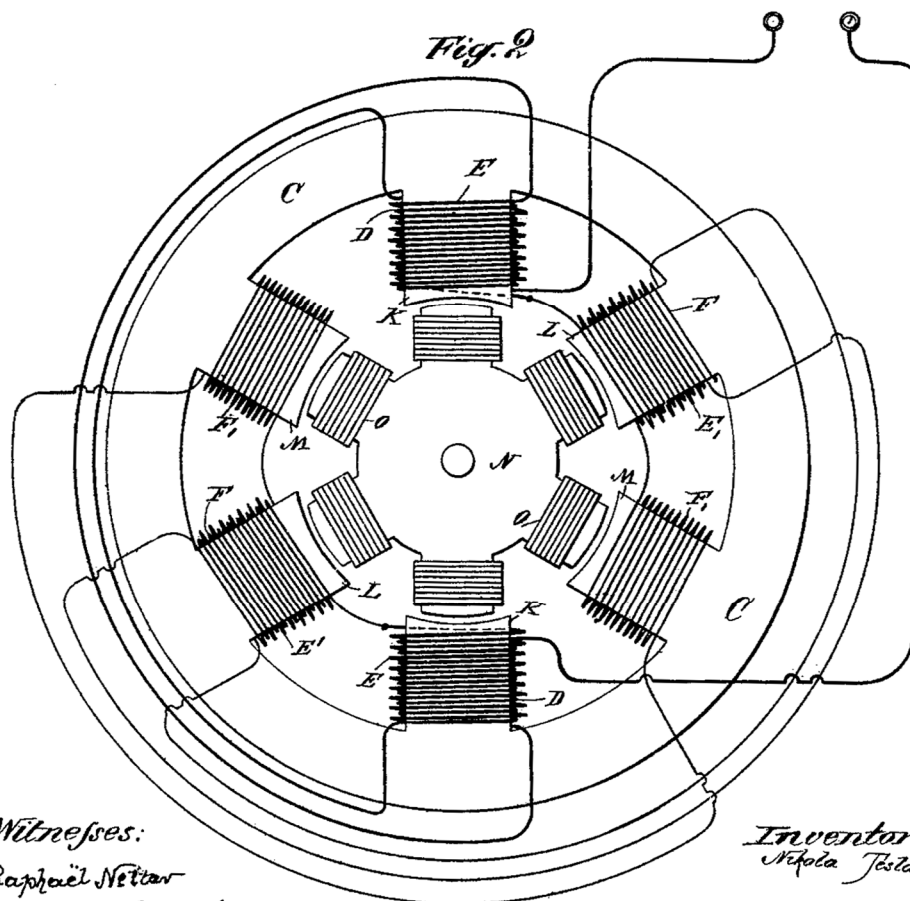


Fig. 2



Witnesses:
Raphaël Netter
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Inventor
Nikola Tesla
by
Duncan, Curtis & Page
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ELECTRIC-ARC LAMP.

电弧灯

NIKOLA TESLA, OF SMILJAN LIKA, AUSTRIA-HUNGARY, ASSIGNOR TO THE TESLA
ELECTRIC LIGHT AND MANUFACTURING COMPANY, OF RAHWAY, NEW JERSEY.

奥匈帝国利卡县史密里安村的尼古拉·特斯拉将专利权转让给
新泽西州拉威市的特斯拉电灯和制造公司。

SPECIFICATION forming part of Letters Patent No. 335,786, dated February 9, 1886.

Application filed March 30, 1885. Serial No. 160,574. (No model.)

该说明书形成了颁发于 1886 年 2 月 9 日编号为 335,786 的专利证书的一部分。

申请于 1885 年 3 月 30 日提交。序列号为 160,574。(没有模型)

To all whom it may concern:

致所有相关人士:

Be it know that I, NIKOLA TESLA, of Smiljan Lika, border country of Austria-Hungary, have
invented certain new and useful Improvements in Electric-Arc Lamps, of which the following is a
specification.

众所周知，我、尼古拉·特斯拉，来自奥匈帝国边境地区的利卡县的史密里安村，在电弧灯
方面已经发明了某些新的有用的改进，以下是该发明一个说明书。

My invention relates more particularly to those arc-lamps in which the separation and feed of the
carbon electrodes or their equivalents is accomplished by means of electromagnets or solenoids in
connection with suitable clutch-mechanism; and it is designed to remedy certain faults common to the
greater part of the lamps heretofore made.

我的发明更具体地涉及这样的弧光灯，其中的碳电极或其等同物的分离和供电是通过与适合
的离合器机制连接的电磁体或螺线管来完成的；并且它被设计来补救迄今为止制造的大部分
电灯所共有的某些缺陷。

The objects of my invention are to prevent the frequent vibrations of the movable electrode and
flickering of the light arising therefrom, to prevent the falling into contact of the electrodes, to
dispense with the dash-pot, clockwork, or gearing and similar devices heretofore used, and to render
the lamp extremely sensitive, and to feed the carbon almost imperceptibly, and thereby obtain a very
steady and uniform light.

我的发明的目的是防止可移动电极的频繁振动和由此产生的光闪烁，防止电极掉落接触，省
去迄今为止使用的减震器、钟表装置或齿轮装置和类似装置，并使灯变得非常灵敏，并且几
乎不可察觉地供给碳料，从而获得非常稳定和均匀的光。

In that class of lamps where the regulation of the arc is effected by forces acting in opposition on a free movable rod or lever directly connected with the electrode, all or some of the forces being dependent on the strength of the current, any change in the electrical condition of the circuit causes a vibration and a corresponding flicker in the light. This difficulty is most apparent when there are only a few lamps in circuit. To lessen this difficulty; lamps have been constructed in which the lever or armature, after the establishing of the arc, is kept in a fixed position and cannot vibrate during the feed operation, the feed-mechanism acting independently; but in these lamps, when a clamp is employed, it frequently occurs that the carbons come into contact and the light is momentarily extinguished, and, frequently, parts of the circuit are injured. In both these classes of lamps it has been customary to use dash-pot, clockwork, or equivalent retarding devices; but these are generally unreliable and objectionable, and increase the cost of construction.

在这类灯中，电弧的调节是通过反向作用在与电极直接连接的自由的、可移动的杆或杠杆上的力来实现的，所有或一些力取决于电流的强度，电路的电气条件的任何变化都会引起光的振动和相应的闪烁。当电路中只有几盏灯时，这种困难最明显。为了减轻这个困难；已经构造了这样的灯，其中在建立电弧之后，杠杆或衔铁保持在一个固定的位置，并且在供料操作期间不能振动，供料机械装置独立地起作用；但是在这些灯中，当使用一个夹具时，经常发生碳与碳接触并且灯瞬间熄灭，并且经常损坏电路的部件。在这两类灯中，通常使用减震器、钟表机械或等效的延迟装置；但是这些通常是不可靠的和令人反感的，并且增加了建造成本。

My invention is intended to effect the desired objects and to remedy the before-mentioned defects. I combine two electro-magnets—one of low resistance in the main or lamp-circuit, and the other of a comparatively high resistance in a shunt around the arc—a movable armature-lever, and a novel feed-mechanism, the parts being arranged so that in the normal working position of the armature-lever the same is kept almost rigidly in one position, and is not effected even by considerable changes in the electric circuit; but if the carbons fall into contact the armature will be actuated by the magnets so as to move the lever and start the arc, and hold the carbons until the arc lengthens and the armature-lever returns to the normal position. After this the carbon rod holder is released by the action of the feed-mechanism, so as to feed the carbon and restore the arc to its normal length.

我的发明旨在实现期望的目的并弥补上述缺陷。我结合了两个电磁体——一个低电阻的电磁体在主电路或灯电路中，而另一个电阻相对较高的电磁体在电弧周围的分流器中——一个可移动的衔铁杠杆，和一个新颖的供料机械装置，这些部件被这样安排，使得衔铁杠杆的正常工作位置几乎刚性地保持在一个位置，甚至不受电路中相当大的变化的影响；但是如果碳掉落并且碳与碳接触，衔铁将被磁体驱动，从而移动杠杆并启动电弧，并抓住碳，直到电弧延长，衔铁杠杆返回到正常位置。此后，碳杆夹具通过供料机械的动作被松开，从而供给碳料并将电弧恢复到其正常长度。

My invention consists, mainly, in the particular manner in which the armature is combined with the magnets and acted upon by them and in the feed-controlling mechanism.

我的发明主要在于衔铁与磁体相结合的特殊方式，并由磁体和供料机械装置进行作用。

In the drawings, Figure 1 is an elevation of the mechanism made use of in the electric lamp. Fig. 2 is a

plan view of the same below the line x x , Fig. 3 is an elevation of the balancing lever and spring, and Fig. 4 is a detached plan view of the pole-pieces and armatures upon the friction-clamp, and Fig. 5 is a section of the clamping-tube.

在附图中，图 1 是电灯中使用的机械装置的一个正视图。图 2 是线 x x 下方的平面图，图 3 是平衡杠杆和弹簧的正视图，图 4 是摩擦夹具上的极靴和衔铁的分离平面图，图 5 是管状夹具（管夹）的截面图。

M is a helix of coarse wire in a circuit from the lower carbon holder to the negative binding-screw.

M 是从下部碳夹持器（用以夹持碳杆）到负极接线螺钉的电路中的一条粗导线螺旋。

N is a helix of the fine wire in a shunt between the positive binding-screw + and the negative binding-screw -. The upper carbon holder S is a parallel rod sliding through the plates S' S² of the frame of the lamp, and hence the electric current passes from the positive binding-post + through the plate S², carbon-holder S, and upper carbon to the lower carbon, and thence by the holder and a metallic connection to the helix M.

N 是位于正极接线螺钉+和负极接线螺钉-之间的一个分流器中的一个细导线螺旋。上部碳夹持器 S 是一个平行的杆，滑动穿过灯的框架板 S' S²，因此电流从正极接线柱+通过板 S²、碳夹持器 S 和上部的碳到达下部的碳，然后通过夹持器和一个金属连接到达螺旋 M。

The carbon-holders are of any desired character, and to insure electric connections the springs l are made use of to grasp the upper carbon holding rod S, but to allow the rod to slide freely through the same. These springs l may be adjusted in their pressure by the screw m, and the spring l may be sustained upon any suitable support. I have shown them as connected with the upper end of the core of the magnet N.

碳夹持器具有任何期望的特征，并且为了确保电连接，利用弹簧 l 来抓住上部的碳夹持杆 S，但是允许杆通过弹簧 l 自由地滑动。这些弹簧 l 的压力可以通过螺钉 m 来调节，并且弹簧 l 可以被支撑在任何合适的支撑物上。我已经展示了它们与磁体 N 的铁芯的上端的连接。

Around the carbon-holding rod S, between the plates S' S², there is a tube, R, which forms a clamp. This tube is counterbored, as seen in the section Fig. 5, so that it bears upon the rod S at its upper end and near the middle, and at the lower end of this tubular clamp R there are armature-segments r of soft iron. A frame or arm, n, extending, preferably, from the core N², supports the lever A by a fulcrum-pin, o. This lever A has a hole, through which the upper end of the tubular clamp R passes freely, and from the lever A is a link, q, to the lever t, which lever is pivoted at y to a ring upon one of the columns S³. This lever t has an opening or bow surrounding the tubular clamp R, and there are pins or pivotal connections w between the lever t and this clamp R, and a spring, r², serves to support or suspend the weight of the parts and balance the same, or nearly so. This spring is preferably adjustable.

在碳夹持杆 S 周围，在板 S' S² 之间，有一个管子 R，它形成一个夹具。如图 5 的截面图所示，该管是扩孔的，因此它在杆 S 的上端和中部附近倚靠在杆 S 上，并且在该管夹 R 的下端有

软铁衔铁分段 r 。最好从铁芯 N^2 延伸的一个框架或臂 n 通过支点销 o 支撑杠杆 A 。该杠杆 A 具有一个孔，管夹 R 的上端自由地穿过该孔，并且从杠杆 A 到杠杆 t 是一个连杆 q ，杠杆 t 在 y 处被枢接到一个柱 S^3 上的环上。该杠杆 t 具有围绕管夹 R 的开口或弓形结构，并且在杠杆 t 和该夹具 R 之间存在销或枢轴连接 w ，并且一个弹簧 r^2 用于支撑或悬挂部件的重量并使它们保持平衡，或者几乎如此。该弹簧最好是可调节的。

At one end of the lever A is a soft iron armature block, a , over the core M' of the helix M , and there is preferably a limiting-screw, c , passing through this armature-block a , and at the other end of the lever A is a soft iron armature-block, b , with the end tapering or wedge-shaped, and the same comes close to and in line with the lateral projection e on the core N^2 . The lower ends of the cores M' N^2 are made with lateral projecting pole-pieces M^3 N^3 , respectively, and these pole-pieces are concave at their outer ends, and are at opposite sides of the armature-segments r at the lower end of the tubular clamp R .

在杠杆 A 的一端是一个软铁衔铁块 a ，它位于螺旋 M 的铁芯 M' 的上方，并且最好有一个限位螺钉 c 穿过该衔铁块 a ，在杠杆 A 的另一端是一个软铁衔铁块 b ，其端部逐渐变细或呈楔形，并且其靠近铁芯 N^2 上的横向突起 e 并与其成一直线。铁芯 M' N^2 的下端分别由横向突出的极靴 M^3 N^3 制成，这些极靴在其外端是凹入的，并且位于管夹 R 下端的衔铁分段 r 的相对两侧。

The operation of these devices is as follows: In the condition of inaction the upper carbon rests upon the lower one, and when the current is turned on the electricity passes freely, by the frame and spring l , through the rod S and carbons to the coarse wire and helix M and to the negative binding-post V , and the core M' thereby is energized. The pole-piece M^3 attracts the armature r , and by the lateral pressure causes the clamp R to grasp the rod S' , and the lever A is simultaneously moved from the position shown by dotted lines, Fig. 1, to the normal position shown in full lines, and in so doing the link q and lever t are raised, lifting the clamp R and the rod S , separating the carbons and forming the arc. The magnetism of the pole-piece e tends to hold the lever A level, or nearly so, the core N^2 being energized by the current in the shunt which contains the helix N . In this position the lever A is not moved by ordinary variation in the electric current because the armature b is strongly attracted by the magnetism of e , and these parts are close to each other, and the magnetism of e acts at right angles to the magnetism of the core M' . If, now, the arc becomes too long, the current through the helix M is lessened, and the magnetism of the core N^3 is increased by the greater current passing through the shunt, and this core N^3 attracting the segmental armature r lessens the hold of the clamp R upon the rod S , allowing the latter to slide and lessen the length of the arc, which instantly restores the magnetic equilibrium and causes the clamp R to hold the rod S . If it happens that the carbons fall into contact, then the magnetism of N^2 is lessened so much that the attraction of the magnet M will be sufficient to move the armature a and lever A so that the armature b passes above the normal position, so as to separate the carbons instantly; but when the carbons burn away a greater amount of current will pass through the shunt until the attraction of the core N^2 will overcome the attraction of the core M' and bring the armature-lever A again into the normal horizontal position, and this occurs before the feed can take place. The segmental armature pieces r are shown as nearly semi-circular. They may be square or of any other desired shape, the ends of the pole-pieces M^3 N^3 being made to correspond in shape.

这些设备的操作如下：在不活动的情况下，上面的碳停留在下面的碳上，当电流接通时，利

用框架和弹簧1，电流自由地通过杆S和碳，到达粗导线和螺旋线M，到达负极接线柱V，从而使铁芯M'被励磁。极靴M³吸引衔铁r，并通过侧向压力使夹具R夹住杆S'，同时杠杆A从图1中虚线所示的位置移动到实线所示的正常位置，在这样做时，连杆q和杠杆t上升，提升夹具R和杆S，使两个碳杆分开并形成电弧。极靴e的磁性倾向于保持杠杆A的水平姿态，或几乎如此，铁芯N²由包含螺旋N的分流器中的电流所激励。在这个位置，杠杆A不会因电流中的任何普通变化而移动，因为衔铁b被e的磁性强烈吸引，这些部分彼此靠近，e的磁性与铁芯M'的磁性成直角来产生动作。如果现在电弧变得太长，通过螺旋M的电流减少，并且通过分流器的更大电流增加了铁芯N³的磁性，并且这个磁性吸引分段衔铁r，减少了夹具R在杆S上的夹持，允许后者滑动并减少电弧的长度，这立即恢复了磁平衡并导致夹具R夹住杆S。如果碰巧发生碳落下并导致碳与碳接触，那么N²的磁性会减弱很多，直到磁体M的吸引力将足以移动衔铁a和杠杆A，使得衔铁b通过正常位置的上方，从而立即将碳与碳分开；但是当碳烧尽时，更大量的电流将通过分流器，直到铁芯N²的吸引力将克服铁芯M'的吸引力，并将衔铁杠杆A再次带到正常的水平位置，这发生在供料发生之前。分段衔铁片r显示为近似半圆形。它们可以是方形或任何其他所需的形状，极靴的末端M³N³被制成相应的形状。

I claim as my invention—

我声称这我的发明是—

1. The combination, in an electric-arc lamp, of the electro-magnets in the main and shunt circuits, respectively, an armature-lever and connection to the movable carbon-holder, the core of the shunt-magnet passing across the end of the armature-lever, substantially as set forth, so that the two magnets act in conjunction on the armature-lever in moving the carbon to form the arc and in opposition to each other beyond the normal position of the armature-lever, substantially as specified.

1、在一个电弧灯中，存在一个组合，它包括分别位于主电路和分流电路中的电磁体；一个衔铁杠杆以及与可运动碳夹持器的连接；还有分流磁体的铁芯，它穿过衔铁杠杆的端部，基本上如所述，从而两个磁体在移动碳以形成电弧的过程中共同作用在衔铁杠杆上，并且在衔铁杠杆的正常位置之外彼此相对，基本按照说明。

2. The combination, with the carbon-holders, of two magnets, one in the main-circuit and an armature-lever to draw the arc, and a feeding-mechanism and pole-pieces upon the electro-magnets to act upon the feeding mechanism, substantially as specified.

2、存在一个组合，它包括碳夹持器；两个磁体，一个在主电路中；一个衔铁杠杆用来引出电弧；以及一个供料机械装置和压在电磁体上的极靴，是用作供料机械装置，基本按照说明。

3. The combination, with the carbon-holders, of two magnets, one in the main-circuit and the other in a shunt-circuit, and an armature-lever between two poles of such electro-magnets to draw the arc, and a feeding-mechanism and pole-pieces upon the other two poles of the electro-magnets to act upon the feeding mechanism, substantially as specified.

3、存在一个组合，它包括碳夹持器；两个磁体，一个在主电路中，另一个在一个分流电路中；这样的电磁体的两极之间的一个衔铁杠杆用来引出电弧；以及一个供料机械装置和压在

电磁体其他两极上的极靴，是用作供料机械装置，基本按照说明。

4. The combination, with the carbon-holding rod in an electric-arc lamp, of the clamp R, lever t, spring r^2 , armature-lever A, and electro-magnets M N in the main and shunt-circuits, respectively, the pole-pieces $M^3 N^3$, and armature-segments r, substantially as set forth.

4、存在一个组合，它包括夹具 R、杠杆 t、弹簧 r^2 、衔铁杠杆 A、在一个电弧灯中的碳夹持杆、分别位于主电路和分流电路中的电磁体 M N、还有极靴 $M^3 N^3$ 、以及衔铁分段 r，基本按照说明。

5. The combination, with the carbon-holder, of a tubular clamp surrounding the same, an armature-lever connected to said tubular clamp, and electro-magnets in the main and shunt-circuits, respectively, and armature-segments upon the tubular clamp adjacent to the lateral poles of the electro-magnets, substantially as set forth.

5、存在一个组合，它包括碳夹持器；围绕该夹持器的一个管夹；一个连接所述管夹的衔铁杠杆；分别位于主电路和分流电路中的电磁体；以及位于管夹上方并且靠近电磁体的横向磁极的电枢分段，基本按照说明。

6. In an electric-arc lamp, the combination, with the carbon-holding rod, of a clamp, two armatures upon the clamp, and electromagnets in the main and shunt-circuits, respectively, the poles of which act upon the armatures of the clamp for bringing the same into action or releasing it, substantially as set forth.

6、在一个电弧灯中，存在一个组合，它包括碳夹持杆；一个夹具；位于夹具上方的两个衔铁；分别位于主电路和分流电路中的电磁体；以及电磁体的磁极，它们作用于夹具的衔铁上使其夹持或释放，基本按照说明。

Signed by me this 25th day of March, A.D. 1885.

本人于公元 1885 年 3 月 25 日签署。

NIKOLA TESLA.

尼古拉·特斯拉

Witnesses:

GEO. T. PINCKNEY,

CHAS. H. SMITH.

见证人：

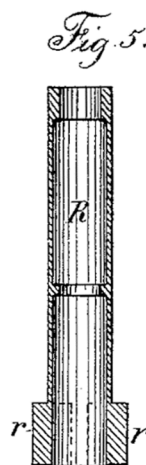
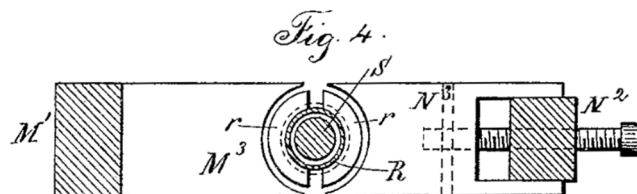
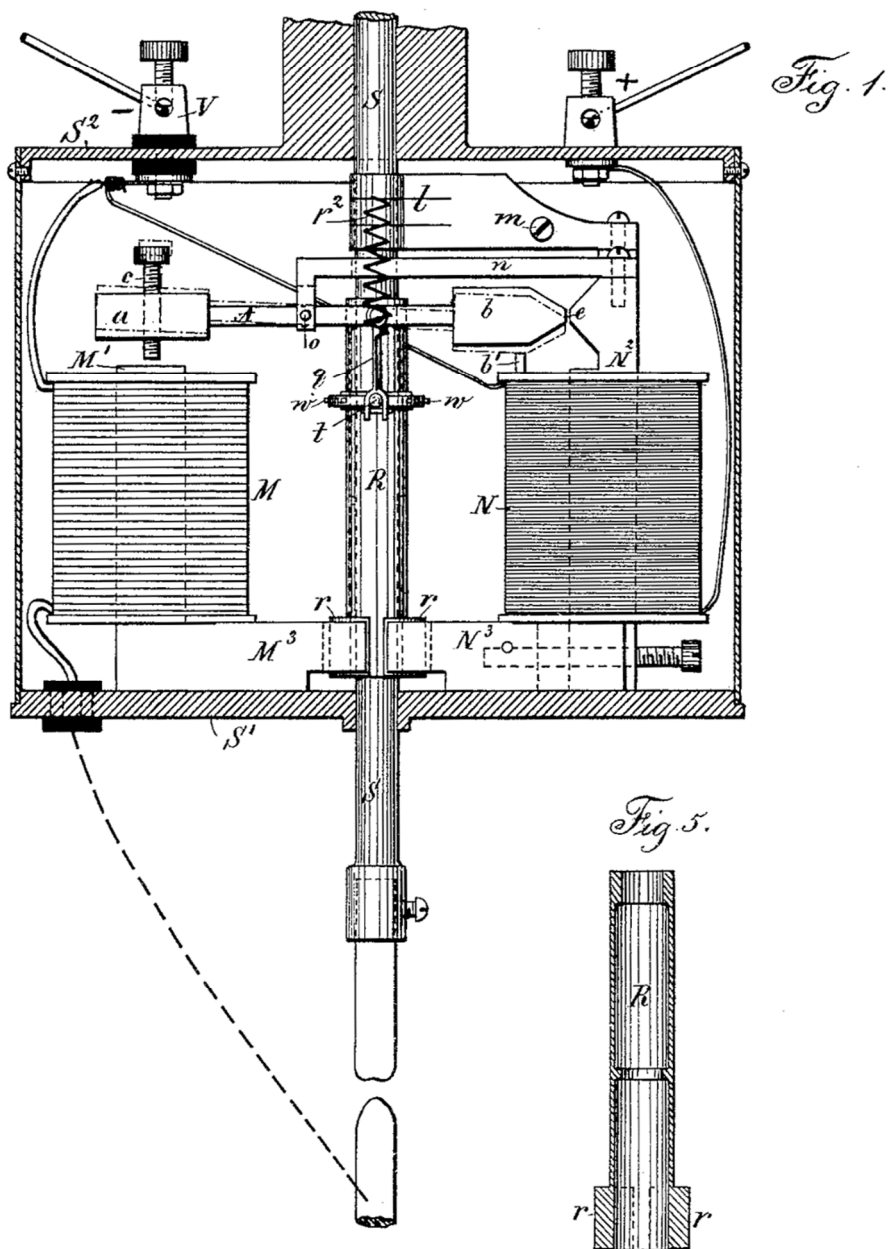
杰奥·T·平克尼、查斯·H·史密斯。

N. TESLA.

ELECTRIC ARC LAMP.

No. 335,786.

Patented Feb. 9, 1886.



Witnesses:
I Staib
Chas. H. Smith

Inventor:
Nikola Tesla
 per *Lemuel W. Perrell*
att'y

N. TESLA.
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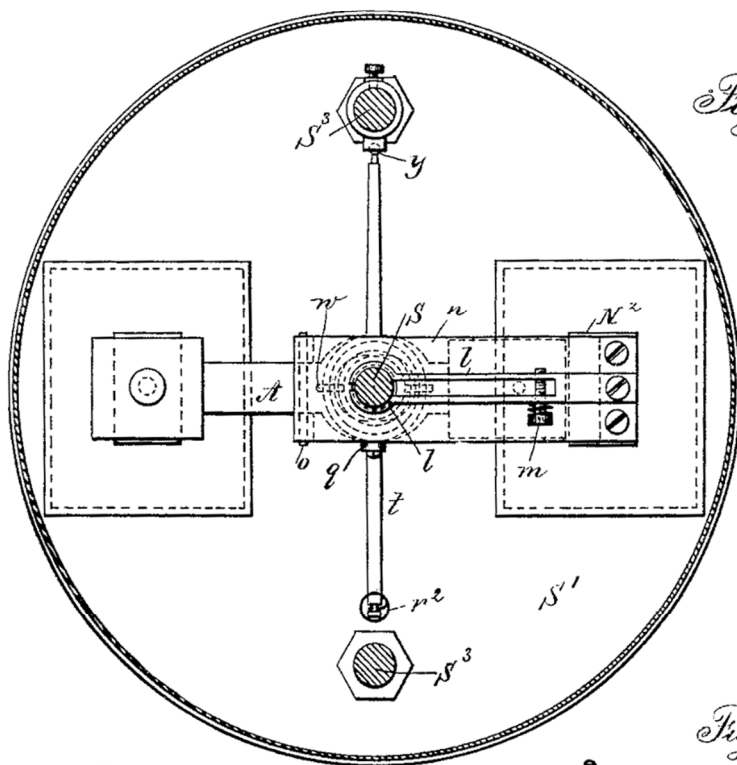


Fig. 2.

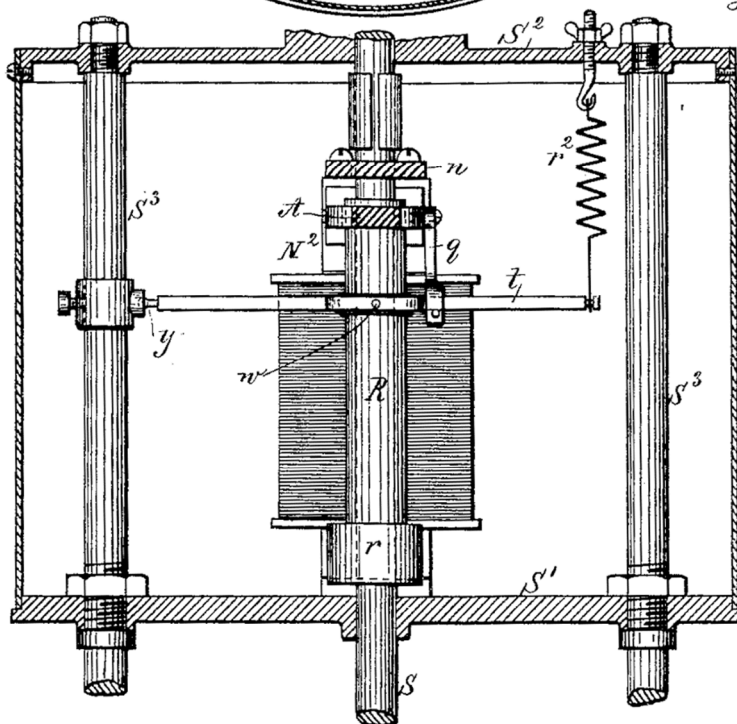


Fig. 3.

Witnesses:

J. Staib
Chas. N. Smith

Inventor:

Nikola Tesla
per Lemuel W. Serrell atty.

ELECTRIC-ARC LAMP.

电弧灯

NIKOLA TESLA, OF SMILJAN LIKA, AUSTRIA-HUNGARY, ASSIGNOR TO THE TESLA
ELECTRIC LIGHT AND MANUFACTURING COMPANY, OF RAHWAY, NEW JERSEY.

奥匈帝国利卡县史密里安村的尼古拉·特斯拉将专利权转让给
新泽西州拉威市的特斯拉电灯和制造公司。

SPECIFICATION forming part of Letters Patent No. 335,787, dated February 9, 1886.

Application filed July 13, 1885. Serial No. 171,416. (No model.)

该说明书形成了颁发于 1886 年 2 月 9 日编号为 335,787 的专利证书的一部分。

申请于 1885 年 7 月 13 日提交。序列号为 171,416。(没有模型)

To all whom it may concern:

致所有相关人士:

Be it known that I, NIKOLA TESLA, of Smiljan Lika, border country of Austria-Hungary, have
invented an Improvement in Electric-Arc Lamps, of which the following is a specification.

众所周知，我、尼古拉·特斯拉，来自奥匈帝国边境地区的利卡县的史密里安村，在电弧灯
方面已经发明了一个新的有用的改进，以下是该发明一个说明书。

In another application, No. 160,574, filed by me March 30, 1885, I have shown and described a lamp
having two magnets, in the main and shunt circuits, respectively, an armature-lever, and feed-
mechanism connected to the armature-lever.

在我于 1885 年 3 月 30 日提交的第 160,574 号申请中，我已经展示并描述了一种灯，该灯具
有两个磁体，分别位于主电路和分流电路中、还有一个衔铁杠杆以及连接到衔铁杠杆上的供
料机械装置。

My present invention consists in some modifications of and improvements upon the devices shown in
the application referred to.

我的本发明在于对所提及的申请中所示的装置进行一些修改和改进。

In my present invention I further provide means for automatically withdrawing a lamp from the circuit,
or cutting out the same, when, from a failure of the feed, the arc reaches an abnormal length, and also
means for automatically reinserting such lamp in the circuit when the rod drops and the carbons come
into contact.

在我的本发明中，我还提供了当由于供料故障，电弧达到异常长度时，用于自动从电路中抽

出灯或切断灯的装置，以及当杆落下且碳与碳接触时，用于自动将这种灯重新插入电路中的工具。

My invention will be understood with reference to the accompanying drawings.

参考附图将会理解我的发明。

In the drawing, Figure 1 is an elevation of the lamp with the case in section. Fig. 2 is a sectional plan at the line x x. Fig. 3 is an elevation, partly in section, of the lamp at right angles to Fig. 1. Fig. 4 is a sectional plan at the line y y of Fig. 1. Fig 5 is a sectional of the clamp in about full size. Fig. 6 is a detached section illustrating the connection of the spring to the lever that carries the pivots of the clamp, and Fig. 7 is a diagram showing the circuit-connections of the lamp.

在附图中，图 1 是灯的一个正视图，带有外壳的一个截面图。图 2 是沿 x x 线的一个截面图。图 3 是与图 1 成直角的灯的局部截面正视图。图 4 是在图 1 的沿着 y y 线的一个截面图。图 5 是大约全尺寸夹具的一个截面图。图 6 是展示弹簧与携带夹具的枢轴的杠杆的连接的一个分离截面图，图 7 是展示灯的电路连接的一个示意图。

In the drawings, Fig. 1, M represents the main and N the shunt magnet, both securely fastened to the base A, which, with its side columns, S S, is preferably cast in one piece of brass or other diamagnetic material. To the magnet are soldered or otherwise fastened the brass washers or disks a a a a. Similar washers, b b, of fiber or other insulating material, serve to insulate the wires from the brass washers.

在附图的图 1 中，M 代表主磁体，N 代表分流磁体，两者都牢固地固定在底座 A 上，底座 A 及其侧柱 S S 最好由黄铜或其它抗磁材料铸造成一体。黄铜垫圈或圆盘 a a a a 被焊接到或以其他方式固定到磁体上。纤维或其他绝缘材料制成的类似垫圈 b b 用于将导线与黄铜垫圈绝缘。

The magnets M and N are made very flat, so that their width exceeds three times their thickness, or even more. In this way a comparatively small number of convolutions is sufficient to produce the required magnetism, besides a greater surface is offered for cooling off the wires.

磁体 M 和 N 被做得很平，以至于它们的宽度超过其厚度的三倍，甚至更多。以这种方式，除了提供更大的表面用于冷却导线之外，相对较小数量的匝数足以产生所需的磁性。

The upper pole-pieces, m n, of the magnets are curved, as indicated in the drawings, Fig. 1. The lower pole-pieces, m' n', are brought near together, tapering toward the armature g, as shown in Figs. 2 and 4. The object of this taper is to concentrate the greatest amount of the developed magnetism upon the armature, and also to allow the pull to be exerted always upon the middle of the armature g. This armature g is a piece of iron in the shape of a hollow cylinder, having on each side a segment cut away, the width of which is equal to the width of the pole-pieces m' n'.

如图 1 所示，磁体的上磁极靴 m n 是弯曲的。如图 2 和图 4 所示，下部磁极靴 m' n' 靠近在一起，朝向衔铁 g 逐渐变细。这种锥形的目的是将大量的产生的磁性集中在衔铁上，并且允许拉力总是施加在衔铁 g 的中间。这个衔铁 g 是一块中空圆筒形状的铁片，在每一侧有一

段被切掉，其宽度等于极靴 $m'n'$ 的宽度。

The armature is soldered or otherwise fastened to the clamp r , which is formed of a brass tube, provided with gripping-jaws $e e$, Fig. 5. These jaws are arcs of a circle of the diameter of the rod R , and are made of some hard metal, preferably of hardened German silver. I also make the guides $f f$, through which the carbon-holding rod R slides, of the same material. This has the advantage to reduce greatly the wear and corrosion of the parts coming in frictional contact with the rod, which frequently causes trouble. The jaws $e e$ are fastened to the inside of the tube r , so that one is a little lower than the other. The object of this is to provide a greater opening for the passage of the rod when the same is released by the clamp. The clamp r is supported on bearings $w w$, Figs. 1, 3 and 5, which are just in the middle between the jaws $e e$. I find this disposition to be the best. The bearings $w w$ are carried by a lever, t , one end of which rests upon an adjustable support, q , of the side columns, S , the other end being connected by means of the link e' to the armature-lever L . The armature-lever L is a flat piece of iron in Z shape, having its ends curved so as to correspond to the form of the upper pole-pieces of the magnets M and N . It is hung upon the pivots $v v$, Fig. 2, which are in the jaw x of the top plate, B . This plate B , with the jaw, is preferably cast in one piece and screwed to the side columns, $S S$, that extend up from the base A . To partly balance the overweight of the moving parts a spring, s' , Figs. 2 and 6, is fastened to the top plate, B , and hooked to the lever t . The hook o is toward one side of the lever or bent a little sidewise, as seen in Fig. 6. By this means a slight tendency is given to swing the armature toward the pole-piece m' of the main-magnet.

衔铁被焊接到或以其他方式固定到夹具 r 上，夹具 r 由一个黄铜管形成，设置有钳口 ee ，见图 5。这些钳口是直径为杆 R 的圆弧，由一些硬金属制成，最好是硬化的锌白铜。我也用同样的材料制作了导轨 ff ，碳夹持杆 R 在其中滑动。这样做的好处是大大减少了与杆摩擦接触的部件的磨损和腐蚀，这些部件经常引起麻烦。钳口 ee 被固定在管 r 的内侧，这样一个钳口比另一个钳口更低一点。这样做的目的是当杆被夹具释放时，为杆的通过提供更大的开口。夹具 r 被支撑在轴承 ww 上，如图 1、3 和 5 所示，轴承 ww 正好位于钳口 ee 之间的中间。我发现这种布置是最好的。轴承 ww 由一个杠杆 t 承载，杠杆 t 的一端停靠在侧柱 S 的一个可调节支撑 q 上，另一端通过连杆 e' 连接到衔铁杠杆 L 。该杠杆是一个 Z 形的扁平铁片，其端部呈圆弧形，以便与磁体 M 和 N 的上极靴的形状相对应。它被悬挂在枢轴 vv 上方，如图 2 所示，枢轴 vv 位于顶板 B 的钳口 x 上。带有钳口的板 B 优选铸造成一个整体，并拧紧到从底座 A 向上延伸的侧柱 SS 上。为了部分平衡移动部件的超重，图 2 和图 6 中的弹簧 s' 被固定在顶板 B 上，并钩在杠杆 t 上。如图 6 所示，钩 o 朝向杠杆的一侧或稍微向侧向弯曲。通过这种方法，有一种轻微的趋势使衔铁向主磁体的极靴 m' 摆动。

The binding-posts $K K'$ are preferably screwed to the base A . A manual switch, for short-circuiting the lamp when the carbons are renewed, is also to be fastened to the base. This switch is of ordinary character, and is not shown in the drawings.

接线柱 $K K'$ 优选用螺钉固定在底座 A 上。一个手动开关，用于在更新碳时使灯短路，也固定在灯座上。该开关具有普通特征，并且未在附图中展示出。

The rod R is electrically connected to the lamp-frame by means of a flexible conductor or otherwise. The lamp-case receives a removable ornamental cover, s^2 , around the same to inclose the parts.

杆 R 通过一个柔性导体或其他方式电连接到灯框上。灯罩在其周围容纳一个可拆卸的装饰盖 s^2 ，以封闭这些部件。

The electrical connections are as indicated diagrammatically in Fig. 7.

电连接如图 7 所示。

The wire in the main magnet consists of two parts, x' and p' . These two parts may be in two separated coils or in one single helix, as shown in the drawings. The part x' being normally in circuit, is, with the fine wire upon the shunt-magnet, wound and traversed by the current in the same direction, so as to tend to produce similar poles, $n n$ or $s s$, on the corresponding pole-pieces of the magnets M and N. The part p' is only in circuit when the lamp is cut out, and then the current being in the opposite direction produces in the main magnet magnetism of the opposite polarity.

主磁体中的导线由两部分组成， x' 和 p' 。如图所示，这两个部分可以是两个分开的线圈或在一个单螺旋中。正常情况下部件 x' 在电路中，细导线缠绕在分流磁体上并通过相同方向的电流，以便在磁体 M 和 N 的相应极靴上产生类似的磁极 $n n$ 或 $s s$ 。只有当灯被切断时，部件 p' 才处在电路中，然后相反方向的电流在主磁体中产生相反极性的磁性。

注：这里的“分流磁体”中的“流”指的是“磁流”，而不是电流。

The operation is as follows: At the start the carbons are to be in contact, and the current passes from the positive binding-post K to the lamp-frame, carbon-holder, upper and lower carbon, insulated return-wire in one of the side rods, and from there through the part x' of the wire on the main magnet to the negative binding-post. Upon the passage of the current the main magnet is energized and attracts the clamping-armature g, swinging the clamp and gripping the rod by means of the gripping-jaws e e. At the same time the armature-lever L is pulled down and the carbons separated. In pulling down the armature-lever L the main magnet is assisted by the shunt-magnet N, the latter being magnetized by magnetic induction from the magnet M.

操作如下:在开始时，碳与碳即将接触，电流从正极接线柱 K 流到灯框、碳夹持器、上部的和下部的碳、侧杆之一中的被绝缘的回线，并从那里通过主磁体上的导线的部件 x' 流到负接线柱。当电流通过时，主磁体被励磁并吸引夹持衔铁 g，摆动夹具并通过钳口 e e 夹紧杆。同时，衔铁杠杆 L 被拉下，碳与碳被分开。在拉下衔铁杠杆 L 的过程中，主磁体得到分流磁体 N 的帮助，分流磁体 N 被来自磁体 M 的磁感应磁化。

It will be seen that the armatures L and g are practically the keepers for the magnets M and N, and owing to this fact both magnets with either one of the armatures L and g may be considered as one horseshoe-magnet, which we might term a “compound-magnet.” The whole of the soft-iron parts m, m', g, n', n, and L form a compound-magnet.

将会看到，衔铁 L 和 g 实际上是磁体 M 和 N 的守门员，并且由于这个事实，具有衔铁 L 和 g 中的任一个的这两个磁体可以被认为是一个马蹄形磁体，我们可以称之为“复合磁体”。整个软铁部件 m、m'、g、n'、n 和 L 的形成一个复合磁体。

The carbons being separated, the fine wire receives a portion of the current. Now, the magnetic induction from the magnet M is such as to produce opposite poles on the corresponding ends of the magnet N; but the current traversing the helices tends to produce similar poles on the corresponding ends of both magnets, and therefore as soon as the fine wire is traversed by sufficient current the magnetism of the whole compound-magnet is diminished.

碳与碳正被分开，细导线接收一部分电流。现在，来自磁体 M 的磁感应使得在磁体 N 的相应端产生相反的磁极；但是穿过螺旋的电流往往会在两个磁体的相应端产生类似的磁极，因此，一旦有足够的电流穿过细导线，整个复合磁体的磁性就会减弱。

With regard to the armature g and operation of the lamp, the pole m' may be termed as the “clamping” and the pole n' as the “releasing” pole.

关于衔铁 g 和灯的操作，磁极 m' 可以称为“夹持”磁极，磁极 n' 可以看作“释放”磁极。

As the carbons burn away, the fine wire receives more current and the magnetism diminishes in proportion. This causes the armature-lever L to swing and the armature g to descend gradually under the weight of the moving parts until the end p, Fig. 1, strikes a stop on the top plate, B. The adjustment is such that when this takes place the rod R is yet gripped securely by the jaws e e. The further downward movement of the armature-lever being prevented, the arc becomes longer as the carbons are consumed, and the compound magnet is weakened more and more until the clamping-armature g releases the hold of the gripping-jaws e e upon the rod R, and the rod is allowed to drop a little, shortening thus the arc. The fine wire now receiving less current, the magnetism increases, and the rod is clamped again and slightly raised, if necessary. This clamping and releasing of the rod continues until the carbons are consumed. In practice the feed is so sensitive that for the greatest part of the time the movement of the rod cannot be detected without some actual measurement. During the normal operation of the lamp the armature-lever L remains stationary, or nearly so, in the position shown in Fig. 1.

随着碳的烧尽，细导线接收到更多的电流，并且磁性按比例减小。这使得衔铁杠杆 L 摆动，衔铁 g 在运动部件的重量作用下逐渐下降，直到图 1 中的端部 p 碰到顶板 B 上的一个挡块。调整是这样的，当这种情况发生时，杆 R 仍然被钳口 e e 牢固地夹紧。衔铁杠杆的进一步向下运动被阻止，随着碳的消耗，电弧变得更长，复合磁体越来越弱，直到夹持衔铁 g 让钳口 e e 释放杆 R，并且允许杆稍微下降，从而缩短电弧。细导线现在接收的电流减少，磁性增加，如果需要，杆再次被夹紧并稍微抬起。杆的这种夹紧和释放一直持续到碳被消耗完。实际上，送料是如此灵敏，以至于在大部分时间里，如果不进行一些实际测量，就无法检测到杆的实际运动。在灯的正常工作中，衔铁杠杆 L 在图 1 所示的位置上保持静止，或几乎静止。

Should it arise that, owing to an imperfection in the rod, the same and the carbons drop too far, so as to make the arc too short, or even bring the carbons in contact, then a very small amount of current passes through the fine wire, and the compound magnet becomes sufficiently strong to act as on the start in pulling the armature-lever L down and separating the carbons to a greater distance.

如果由于杆中的缺陷，杆和碳下降得太大，以至于电弧太短，甚至使碳与碳接触，那么很少量的电流通过细导线，复合磁体变得足够强，开始拉动衔铁杠杆 L 并将碳与碳分开到更大的

距离。

It occurs often in practice that the rod sticks in the guides. In this case the arc reaches a great length, until it finally breaks. Then the light goes out, and frequently the fine wire is injured. To prevent such an accident, I provide my lamp with an automatic cut-out. This cut-out operates as follows: When, upon a failure of the feed, the arc reaches a certain predetermined length, such an amount of current is diverted through the fine wire that the polarity of the compound magnet is reversed. The clamping-armature *g* is now moved against the shunt-magnet *N* until it strikes the releasing-pole *n'*. As soon as the contact is established, the current passes from the positive binding-post over the clamp *r*, armature *g*, insulated shunt-magnet, and the helix *p'* upon the main magnet *M* to the negative binding post. In this case the current passes in the opposite direction and changes the polarity of the magnet *M*, at the same time maintaining by magnetic induction in the core of the shunt-magnet the required magnetism without reversal of polarity, and the armature *g* remains against the shunt-magnet pole *n'*. The lamp is thus cut out as long as the carbons are separated. The cut-out may be used in this form without any further improvement; but I prefer to arrange it so that if the rod drops and the carbons come in contact the arc is started again. For this purpose I proportion the resistance of the part *p'* and the number of the convolutions of the wire upon the main magnet so that when the carbons come in contact a sufficient amount of current is diverted through the carbons and the part *x'* to destroy or neutralize the magnetism of the compound magnet. Then the armature *g*, having a slight tendency to approach to the clamping-pole *m'*, comes out of contact with the releasing-pole *n'*. As soon as this happens, the current through the part *p'* is interrupted, and the whole current passes through the part *x*. The magnet *M* is now strongly magnetized, the armature *g* is attracted, and the rod clamped. At the same time the armature-lever *L* is pulled down out of its normal position and the arc started. In this way the lamp cuts itself out automatically when the arc gets so long, and reinserts itself automatically in the circuit if the carbons drop together.

在实践中经常发生杆卡在导轨中的情况。在这种情况下，电弧达到一个很大的长度，直到它最终断裂。然后灯熄灭，细导线经常受损。为了防止这样的事件，我给我的灯安装了一个自动断电装置。这种切断操作如下：当送料失败时，电弧达到某一预定长度，这样的电流通过细导线改道，使得复合磁体的极性反转。夹持衔铁 *g* 现在移向分流磁体 *N*，直到它碰到释放磁极 *n'*。一旦建立了接触，电流就从正极接线柱经过夹具 *r*、衔铁 *g*、被绝缘的分流磁体和主磁体 *M* 上的螺旋 *p'* 流到负极接线柱。在这种情况下，电流以相反的方向通过，并改变磁体 *M* 的极性，同时通过分流磁体的铁芯中的磁感应维持所需的磁性而不反转极性，衔铁 *g* 保持抵靠分流磁极 *n'*。只要碳与碳被分开，灯就被切断。切断可以这种形式使用，无需任何进一步的改进；但我更喜欢这样布置，如果杆落下，碳与碳发生接触，电弧会再次开始。为此，我使得 *p'* 部件的电阻与主磁体上导线的圈数成正比例，以便当碳与碳接触时，足够量的电流通过碳和 *x'* 部件改道，以破坏或抵消复合磁体的磁性。然后，衔铁 *g* 稍微倾向于靠近夹持磁极 *m'*，与释放磁极 *n'* 脱离接触。一旦发生这种情况，通过 *p'* 部件的电流被中断，整个电流通过 *x* 部件。磁体 *M* 现在被强磁化，衔铁 *g* 被吸引，杆被夹紧。同时，衔铁杠杆 *L* 被拉下离开其正常位置，电弧开始。这样，当电弧变得很长时，灯会自动切断，如果碳与碳一起掉落，灯会自动重新插入电路中。

It will be seen that the cut-out may be modified without departing from the spirit of my invention, as long as the shunt-magnet closes a circuit including a wire upon the main magnet and continues to keep the contact closed, being magnetized by magnetic induction from the main magnet. It is also obvious

to say that the magnets and armatures may be of any desired shape.

可以看出，在不偏离本发明的精神的情况下，只要分流磁体闭合包含了主磁体上的导线的电路，并继续保持触点闭合（触点正被主磁体的磁感应所磁化），就可以修改切断。同样显而易见的是，磁体和衔铁可以是任何期望的形状。

I claim as my invention—

我主张我的发明是—

1. The combination, in an arc-lamp, of a main and a shunt magnet, an armature-lever to draw the arc, a clamp, and an armature to act upon the clamp, a clamping-pole and a releasing-pole upon the respective cores, the cores, poles, armature-lever, and clamping-armature forming a compound electro-magnet, substantially as set forth.

1、在一个电弧灯中，一个主磁体和一个分流磁体、吸引电弧的一个衔铁杠杆、一个夹具和作用在夹具上的一个衔铁、以及各自铁芯上的夹持磁极和释放磁极的组合，铁芯、磁极、衔铁杠杆和夹持衔铁形成复合电磁体，基本如前所述。

2. The combination, in an electric-arc lamp, of a carbon-holder and its rod, a clamp for such carbon-holder, a clamping-armature connected to the clamp, a compound electro-magnet controlling the action of the clamping-armature, and electric-circuit connections, substantially as set forth, for lessening the magnetism of the compound magnet when the arc between the carbons lengthens and augmenting the magnetism of the same when the arc is shortened, substantially as described.

2、在一个电弧灯中，一个碳夹持器及其杆、用于这种碳夹持器的夹具、连接到夹具的夹持衔铁、控制夹持衔铁的动作的复合电磁体以及电路连接的组合，基本如上所述，用于当碳与碳之间的电弧变长时减小复合磁体的磁性，而当电弧变短时增大复合磁体的磁性，基本如所述。

3. The combination, with the carbon-holders in an electric lamp, of a clamp around the rod of the upper carbon holder, the clamping-armature connected with said clamp, the armature-lever and connection from the same to the clamp, the main and shunt magnets, and the respective poles of the same to act upon the clamping-armature and armature-lever, respectively, substantially as set forth.

3、存在一个组合，它包括一个电灯中的碳夹持器、围绕上部碳夹持器的杆的一个夹具、与所述夹具连接的夹持衔铁、衔铁杠杆和从该杠杆到夹具的连接、主磁体和分流磁体、以及分别作用在夹持衔铁和衔铁杠杆上的主磁体和分流磁体的相应磁极，基本上如所述。。

4. In an electric-arc lamp, a cut-out consisting of a main magnet, an armature, and a shunt-magnet having an insulated pole-piece, and the cut-out circuit-connections through the pole-piece and armature, substantially as set forth.

4、在一个电弧灯中，一个由主磁体、衔铁和具有绝缘极靴的分流磁体组成的断流器，以及通过极靴和衔铁的断流器电路连接，基本如前所述。

5. In an electric-arc lamp, the combination, with the carbon-holder and magnets, of the armatures L and g, link e', clamp r, and lever t, and the spring s', for the purpose set forth.

5、在一个电弧灯中，一个包括衔铁 L 和 g、连杆 e'、夹具 r 和杠杆 t、弹簧 s' 与碳夹持器和磁体的组合，用于所述目的。

6. In an electric-arc lamp, the combination, with two upright magnets in the main and shunt circuits, respectively, having curved pole-pieces on one end and converging pole-pieces on the other end, of a flat z-shaped armature-lever between the curved pole-pieces and a clamping-armature between the convergent pole-pieces, substantially as described.

6、在一个电弧灯中，存在一个组合，它包括两个分别位于主电路和分流电路中的直立磁体，它在一端具有圆弧形极靴，在另一端具有会聚的极靴；在弯曲的极靴之间具有一个扁平的 z 形衔铁杠杆，在会聚的极靴之间具有一个夹持衔铁，基本上如所述。

7. The combination, in an electric-arc lamp, of an electro-magnet in the main circuit and an electro-magnet in the shunt-circuit, an armature under the influence of the poles of the respective magnets, and circuit-connections controlled by such armature to cut out or shunt the lamp, substantially as specified, whereby the branch circuit is closed by the magnetism of the shunt-magnet, and then kept closed by induced magnetism from the main magnet, substantially as set forth.

7、在一个电弧灯中，存在一个组合，它包括主电路中的电磁体和分流电路中的电磁体；在相应磁体的磁极的影响下的衔铁；以及由这种衔铁控制的电路连接；以基本上按照说明被切断或被分流的灯，基本如所述，因此分支电路利用分流磁体的磁性闭合，然后利用来自主磁体的感应磁性保持闭合，基本如上所述。

8. The combination, with the carbon-holder and rod and the main and shunt magnets, of a feeding-clamp, an armature for the same, clamping and releasing poles upon the cores of the respective magnet, and circuit-connections through the clamping-armature, substantially as specified, for shunting the current when the electric arc between the carbons becomes abnormally long, substantially as set forth.

8、存在一个组合，它包括碳夹持器和杆以及主磁体和分流磁体；一个供料夹具；用于供料夹具的一个衔铁；在相应磁体的铁芯上的夹持磁极和释放磁极；以及通过夹持衔铁的电路连接，基本上如所述，用于当碳与碳之间的电弧变得异常长时分流电流，基本如上所述。

9. The combination, with the carbon-holding rod and a clamp for the same, of an armature upon the clamp, a shunt-magnet the pole of which acts to release the clamp, and a main magnet with a two-part helix, one portion being in the main circuit and the other portion in a shunt or cut-out circuit, the clamping-armature acting to close said cut-out circuit when the arc becomes too long and to break the shunt-circuit when the carbons come together, substantially as set forth.

9、存在一个组合，它包括碳夹持杆和用于该杆的一个夹具；该夹具上的一个衔铁；一个分流磁体，其磁极用于释放夹具；以及带有两个螺旋部分的一个主磁体、一部分在主电路中，另一部分在分流或断路电路中；夹具衔铁用于闭合所述断路电路，当碳与碳碰到在一起时，断开分流电路，基本上如所述。

Signed by me this 11th day of July, A.D. 1885.
本人于公元 1885 年 7 月 11 日签署。

NIKOLA TESLA.
尼古拉·特斯拉

Witnesses:

GEO. T. PINCKNEY,
WILLIAM G. MOTT.

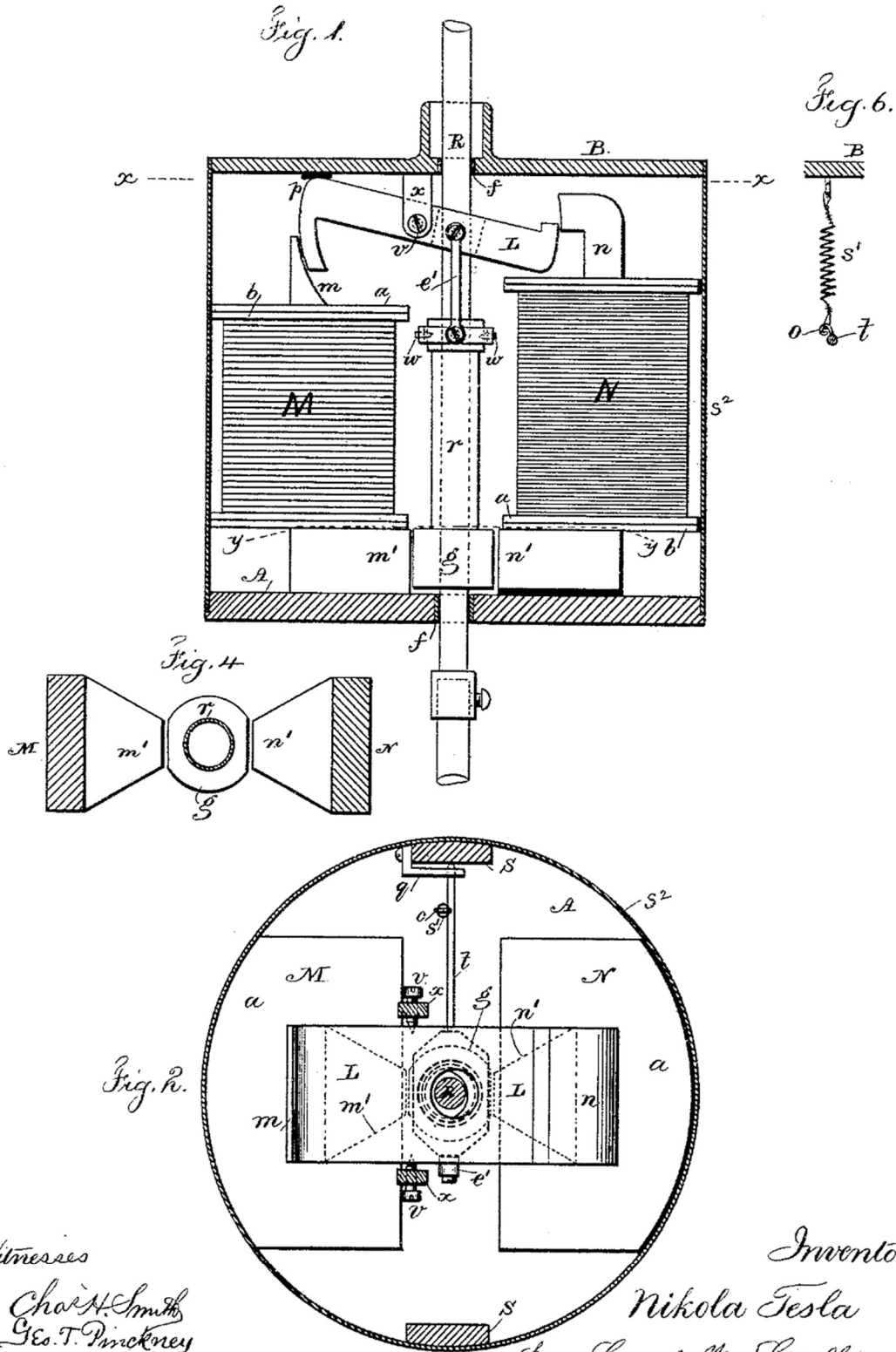
见证人:

杰奥·T·平克尼、威廉·G·墨特。

N. TESLA.
ELECTRIC ARC LAMP.

No. 335,787.

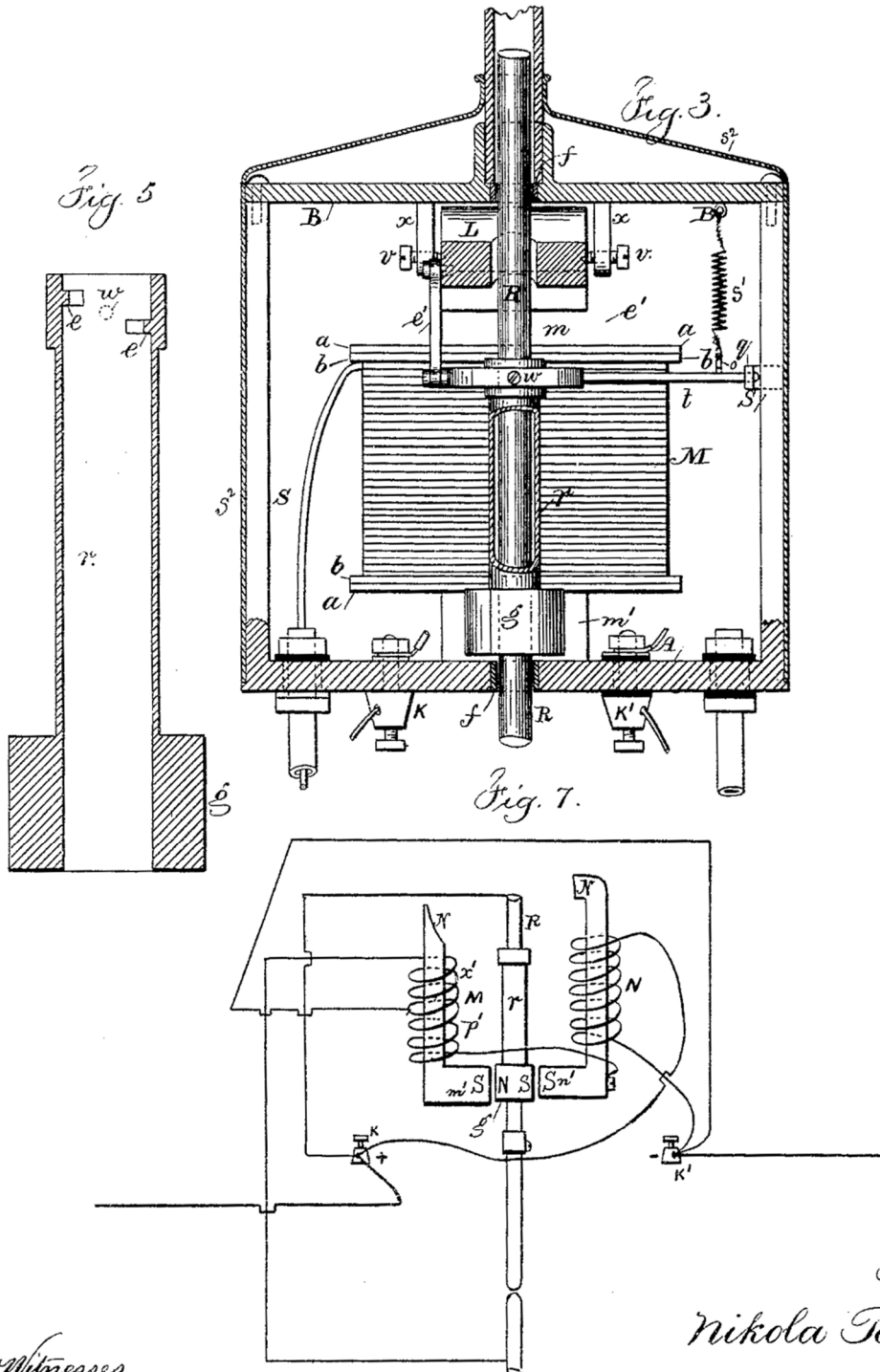
Patented Feb. 9, 1886.



N. TESLA.
ELECTRIC ARC LAMP.

No. 335,787.

Patented Feb. 9, 1886.



Witnesses

Chas. H. Smith
Geo. T. Pinckney

Inventor

Nikola Tesla

For Lemuel W. Serrell

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METHOD OF OPERATING ARC-LAMPS.

运行弧光灯的方法

NIKOLA TESLA, OF NEW YORK, N.Y.

纽约州纽约市的尼古拉·特斯拉

SPECIFICATION forming part of Letters Patent No. 447,920, dated March 10, 1891.

Application filed October 1, 1890. Serial No. 366,734. (No model.)

该说明书形成了颁发于 1891 年 3 月 10 日编号为 447,920 的专利证书的一部分。

原始申请于 1890 年 10 月 1 日提交，序列号 366,734。(没有模型)

To all whom it may concern:

致所有相关人士:

Be it known that I, NIKOLA TESLA, a subject of the Emperor of Austria-Hungary, residing at New York, in the county and State of New York, have invented certain new and useful Improvements in Methods of Operating Arc Lamps, of which the following is a specification.

众所周知，我、尼古拉·特斯拉、奥匈帝国皇帝的一位臣民，居住在纽约州纽约郡纽约市，在运行弧光灯的方法方面已经发明了某些新的和有用的改进，以下是该发明一个说明书。

This invention consists in an improved method of operating electric-arc lamps which are supplied with alternating or pulsating currents.

本发明在于一种运行电弧灯的改进后的方法，该电弧灯被供给交流或脉动电流。

It has now become a common practice to run arc lamps by alternating or pulsating as distinguished from continuous currents; but an objection to such systems exists in the fact that the arcs emit a pronounced sound, varying with the rate of the alternations or pulsations of current, but under any circumstances constituting an objectionable and disagreeable feature, for which heretofore no effective remedy has been found or proposed. This noise is probably due to the rapidly alternating heating and cooling and consequent expansion and contraction of the gaseous matter forming the arc which corresponds with the periods or impulses of the current, for I have succeeded in abating it and producing quiet and smoothly-acting lamps by increasing, per unit of time, the number of alternations or pulsations of the current producing the arc to such an extent that the rate of the vibrations or changes in the arc producing the noise approximately equals or exceeds that which is generally regarded as the limit of audition. For example, I may use a generator which produces ten thousand or more alternations of current per second. In such a case the periodical heating and cooling of the arc would occur with such rapidity as to produce little or no perceptible effect upon the ear.

区别于恒向电流，通过交流或脉动来运行弧光灯现在已经成为一种普遍的做法；但是对这种

系统的一个缺陷存在于这样的事实中，电弧发出明显的声音，随着电流的交替或脉动的速率而变化，在任何情况下都构成令人讨厌和不愉快的特征，迄今为止还没有发现或提出有效的补救措施。这种噪音可能是由于快速交替地加热和冷却以及由此导致的形成电弧的气体物质的膨胀和收缩，这与电流的周期或脉冲相对应，因为我已经成功地消除了这种噪音，并通过增加每单位时间内产生电弧的电流的交替或脉动的次数，使产生噪音的电弧的振动或变化的速率大约等于或超过通常认为的听觉极限，生产了安静的和动作平稳的灯。例如，我可以使用一台每秒产生一万次或更多次交变电流的发电机。在这种情况下，电弧的周期性加热和冷却会以如此快的速度发生，以至于对耳朵产生很小的或不可察觉的影响。

There are a number of ways in which the current may be varied at a rate exceeding the limit of audition, but probably the most practicable known to me at present is by the use of an alternating-current generator with a large number of poles and specially constructed for the purpose. Such a generator, for the purpose of the illustration of this case, I have shown in the accompanying drawings.

有许多方法可以使电流以超过听力极限的速率变化，但可能是目前我所知道的最可行的是使用具有大量磁极的和专门为此目的而建造的一台交流发电机。这样的一台发电机，为了说明这种情况，我已经在附图中展示出。

Figure 1 is a view of the generator in side elevation. Fig. 2 is a vertical cross-section of the same with a diagram of the circuit-connections. Fig. 3 is an enlarged view, in side elevation, of a part of the machine. Fig. 4 is an enlarged sectional detail of the armature and field. Fig. 5 is a detail section of the field-magnets exhibiting the plan of winding.

图 1 是发电机的侧视图。图 2 是带有电路连接图的垂直截面图。图 3 是机器一部分的放大侧视图。图 4 是放大后的电枢和磁场的详细截面图。图 5 是展示了绕组平面的场磁体的一个详细截面图。

A is an annular magnetic frame supported by the cross-bars or brackets B, provided with feet C, upon which the machine rests. The interior of the annulus A is provided with a large number of projections or pole-pieces D. These may be formed or applied in a variety of ways—as, for example, by milling transverse grooves E.

A 是由横杆或支架 B 支撑的环形磁性框架，配有支脚 C，机器放置在支脚 C 上。环 A 的内部配有大量的突起或极靴 D。这些可以以多种方式形成或应用，例如，通过铣削横向沟槽 E。

Owing to the very large number and small size of the poles and the spaces between them, I apply the exciting or field coils by winding an insulated conductor F zigzag through the grooves, as shown in Fig. 5, carrying said wire around the annulus to form as many layers as is desired. In this way the pole-pieces D will be energized with alternately opposite polarity around the entire ring.

由于磁极的数量巨大，磁极的尺寸与磁极之间的距离都非常小，我通过沿着之字形路线穿过沟槽在一个被绝缘的导体 F 上缠绕施加激励或励磁的线圈，如图 5 所示，将所述导线围绕在圆环上以形成所需的任意层数。这样，极靴 D 将被环绕整个圆环的交替相反的极性所激励。

For the armature I employ a spider or circular frame G on a driving-shaft H, mounted in bearings in

the brackets B. This spider carries a ring J, turned down, except at its edges, to form a trough-like receptacle for a mass of fine annealed iron wires K, which are wound in the groove to form the core proper for the armature-coils. Pins L are set in the sides of the ring J, and the coils M are wound over the periphery of the armature-structure and around the pins. The coils M are connected together in series, and these terminals N carried through the hollow shaft H to contact-rings P P, from whence the currents are taken off by brushes O. In this way a machine with a very large number of poles may be constructed. It is easy, for instance, to obtain in this manner three hundred and seventy-five to four hundred poles in a machine that may be safely driven at a speed of fifteen hundred or sixteen hundred revolutions per minute, which will produce ten thousand or eleven thousand alternations of current per second. Arc lamps R R are shown in diagram as connected up in series with the machine in Fig. 2. If such a current be applied to running arc lamps, the sound produced by or in the arc becomes practically inaudible, for by increasing the rate of change in the current, and consequently the number of vibrations per unit of time of the gaseous material of the arc up to or beyond ten thousand or eleven thousand per second, or to what is regarded as the limit of audition, the sound due to such vibrations will not be audible. The exact number of changes or undulations necessary to produce this result will vary somewhat according to the size of the arc—that is to say, the smaller the arc the greater the number of changes that will be required to render it inaudible within certain limits. Of course, as the rate of alternations or undulations for a given size of arc becomes very high the sound produced is less perceptible, and hence for some purposes the actual limit of audition may only be approached, provided the sound be rendered practically inaudible.

对于电枢我采用了一个蜘蛛形或圆形框架 G，被安装在一个驱动轴 H 上，该驱动轴被安装在轴承的支架 B 上。这个蜘蛛形框架携带一个圆环 J，除了在边缘外，它被向下翻转，形成一个槽状的容器，用于容纳大量的退火细铁丝 K，这些铁丝缠绕在沟槽中形成电枢线圈的铁芯。销 L 设置在环 J 的侧面，线圈 M 缠绕在电枢结构的外围上方并绕在销的周围。线圈 M 被串联在一起，这些终端 N 通过空心轴 H 连接到接触环 P P，从那里电流被电刷 O 取走。以这种方式，可以构造具有大量磁极的机器。例如，很容易以这种方式获得 375 个到 400 个磁极的机器，可以安全地以每分钟 1500 转或 1600 转的速度驱动，这将产生每秒 10000 次或 11000 次电流交替。弧光灯 R R 如图 2 所示与图中的机器串联。如果将这样的电流施加到运行的弧光灯上，电弧产生的声音或电弧中的声音就实际上不会被听见，因为通过增加电流的变化速率，从而将弧光灯气体材料在单位时间的振动次数增加到或超过每秒一万次或一万一千次，或者增加到被认为是听觉极限的程度，由这种振动产生的声音将是听不见的。产生这种结果所需的变化或波动的确切数量将根据电弧的大小而有所不同，也就是说，电弧越小，在一定限度内使其听不见所需的变化数量就越大。当然，对于给定大小的电弧，随着交替或波动的速率变得非常高时，所产生的声音就不太容易被察觉，因此对于某些目的来说，如果声音变得几乎听不见，就可以接近听觉的实际极限。

Another advantage gained by increasing as above set forth the number of alternations is that the arc acts more like that produced by a continuous current, in that it is more persistent, owing to the fact that the time interval between undulations is so small that the gaseous matter cannot cool down so far as to increase very considerably in resistance.

通过增加如上所述的交替次数而获得的另一个优点是，电弧更像由恒向电流产生的电弧，因为它更持久，这是由于波动之间的时间间隔如此之小，以至于气体物质不能冷却到电阻大大增加的程度。

I claim—

我主张——

The method of abating or rendering inaudible the sound emitted by arc lamps supplied with or operated by an alternating or pulsating current by increasing the rate of such alternations or pulsations up to that of the limit of audition, as set forth.

通过将交流或脉动的速率增加到听觉极限,来减弱或使由交流或脉动电流供电或运行的弧光灯发出的声音变得听不见的方法。

NIKOLA TESLA.

尼古拉·特斯拉

Witnesses:

FRANK B. MURPHY,

RAPHAËL NETTER.

见证人:

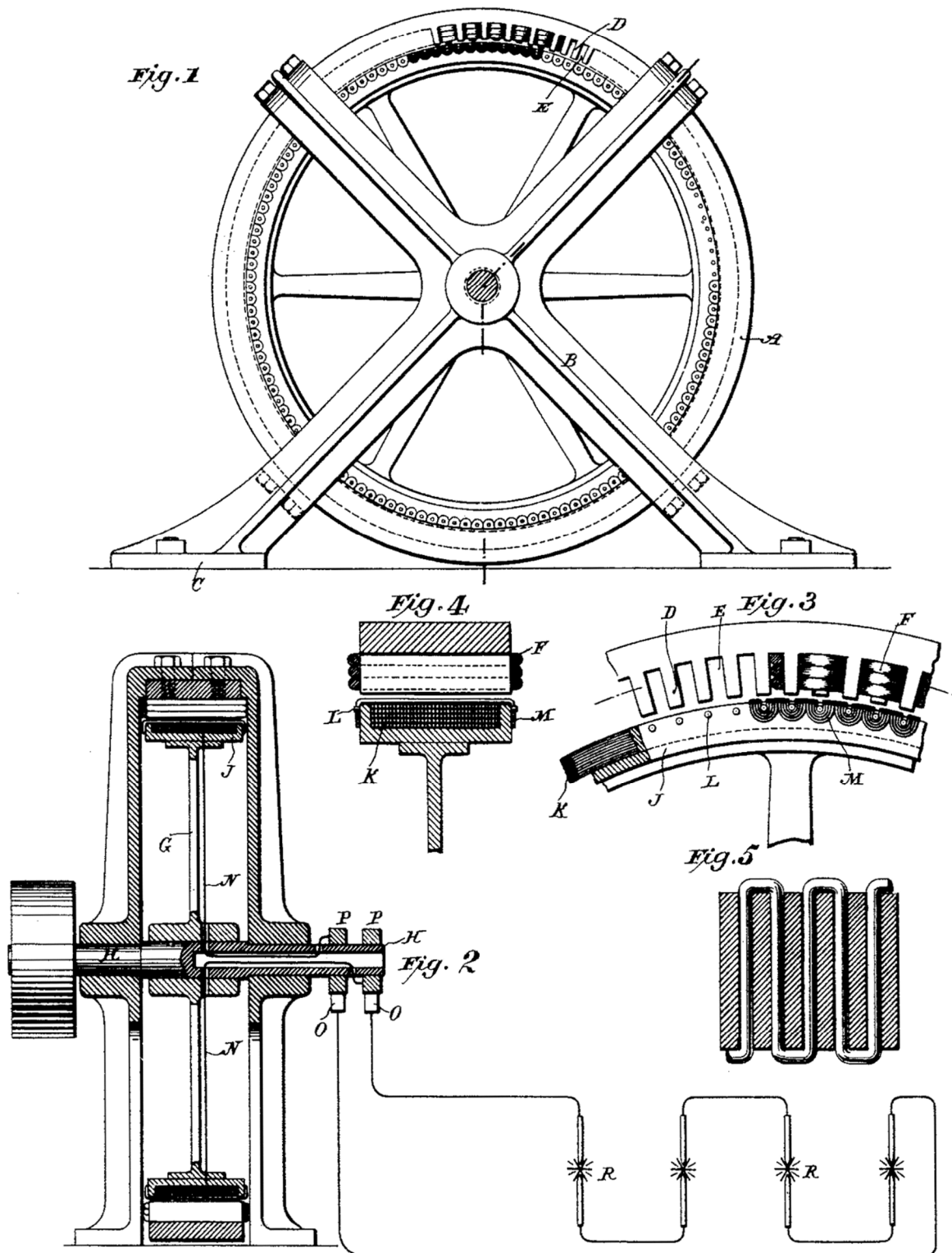
弗兰克·墨菲、拉斐尔·奈特。

(No Model.)

N. TESLA.
METHOD OF OPERATING ARC LAMPS.

No. 447,920.

Patented Mar. 10, 1891.



Witnesses:
Raphaël Netter
M. G. Travy

Inventor
Nikola Tesla
by
Duncan & Page
Attorneys

SYSTEM OF ELECTRIC LIGHTING.

电力照明系统

NIKOLA TESLA, OF NEW YORK, N. Y.

纽约州纽约市的尼古拉·特斯拉

SPECIFICATION forming part of Letters Patent No. 454,622, dated June 23, 1891.

Application filed April 25, 1891. Serial No. 390,414. (No model.)

该说明书形成了颁发于 1891 年 6 月 23 日编号为 454,622 的专利证书的一部分。

申请于 1891 年 4 月 25 日提交。序列号 390,414。(没有模型)

To all whom it may concern:

致所有相关人士:

Be it known that I, NIKOLA TESLA, a subject of the Emperor of Austria-Hungary, from Smiljan, Lika, border country of Austria-Hungary, and a resident of New York, in the county and State of New York, have invented certain new and useful Improvements in Methods of and Apparatus for Electric Lighting, of which the following is a specification, reference being had to the drawings accompanying and forming a part of the same.

众所周知，我、尼古拉·特斯拉、奥匈帝国皇帝的一位臣民，来自奥匈帝国边境地区的利卡县的史密里安村，并且是一位居住在纽约州纽约郡纽约市的居民，在电力照明的方法和装置方面已经发明了某些新的和有用的改进，以下是该发明一个说明书，必须参考随附的图纸，它已形成了该说明书的一部分。

This invention consists in a novel method of and apparatus for producing light by means of electricity.

本发明包括利用电来产生光的一种新颖的方法和装置。

For a better understanding of the invention it may be stated, first, that heretofore I have produced and employed currents for very high frequency for operating translating devices, such as electric lamps, and, second, that currents of high potential have also been produced and employed for obtaining luminous effects, and this, in a broad sense, may be regarded for purposes of this case as the prior state of the art; but I have discovered that results of the most useful character may be secured under entirely practicable conditions by means of electric currents in which both the above-described conditions of high frequency and great difference of potential are present. In other words, I have made the discovery that an electrical current of an excessively small period and very high potential may be utilized economically and practicably to great advantage for the production of light.

为了更好地理解本发明，可以说，首先，迄今为止我已经生产并采用了用于操作转换装置（比如电灯）的甚高频电流，其次，也已经产生并采用了高电势的电流来获得发光效果，从广义

上来说，这可以被视为用于本案目的的现有技术；但我发现，在完全可行的条件下，通过同时出现上述高频和大电位的条件，可以确保获得具有最有用的特性的结果。换句话说，我已经发现，可以经济且实用地利用极短周期和非常高电位的电流，从而在产生光方面获得极大的优势。

It is difficult for me to define the exact limits of frequency and potential within which my discovery is comprised, for the results obtained are due to both conjointly; but I would make it clear that as to the inferior limits of both, the lowest frequency and potential that I contemplate using are far above what have heretofore been regarded as practicable. As an instance of what I regard as the lowest practicable limits I would state that I have obtained fairly good results by a frequency as low as fifteen thousand to twenty thousand per second and a potential of about twenty thousand volts. Both frequency and potential may be enormously increased above these figures, the practical limits being determined by the character of the apparatus and its capability of standing the strain. I do not mean by the term “excessively small period” and similar expressions herein to imply that I contemplate any number of pulsations or vibrations per second approximating to the number of light-waves, and this will more fully appear from the description of the nature of the invention which is hereinafter contained.

对我来说，很难定义我的发现所包含的频率和电势的确切极限，因为所获得的结果是两者共同的结果；但我要清楚地表明，至于两者的下限，我打算使用的最低的频率和电势也要远远高于迄今为止被认为是可行的频率和电势。作为我所认为的最低可行极限的一个例子，我要声明我已经获得了相当好的结果，频率低至每秒 15000 次到 20000 次，电势约为 20000 伏。频率和电位都可以在这些数字之上大大增加，实际极限取决于设备的特性及它们的承受应变的能力。我在这里所说的术语“过小周期”和类似的表达方式并不是暗示我考虑每秒接近光波数量的任何数量的脉动或振动，这将从下文包含的本发明的性质的描述中更充分地显现出来。

The carrying out of this invention and the full realization of the conditions necessary to the attainment of the desired results involve first, a novel method of and apparatus for producing the currents or electrical effects of the character described; second, a novel method of utilizing and applying the same for the production of light, and, third, a new form of translating device or light-giving appliance. These I shall now describe.

实施本发明和充分实现获得所需结果所必需的条件首先涉及一种用于产生所述特性的电流或电效应的新方法和装置；其次，一种利用和应用其产生光的新方法，最后，新形式的转换装置或发光设备。我现在将描述这些。

To produce a current of very high frequency and very high potential, certain well-known devices may be employed. For instance, as the primary source of current or electrical energy a continuous-current generator may be used, the circuit of which may be interrupted with extreme rapidity by mechanical devices, or a magneto-electric machine specially constructed to yield alternating currents of very small period may be used, and in either case, should the potential be too low, an induction-coil may be employed to raise it; or, finally, in order to overcome the mechanical difficulties, which in such cases become practically insuperable before the best results are reached, the principle of the disruptive discharge may be utilized. By means of this latter plan I produce a much greater rate of change in the current than by the other means suggested, and in illustration of my invention I shall confine the

description of the means or apparatus for producing the current to this plan, although I would not be understood as limiting myself to its use. The current of high frequency, therefore, that is necessary to the successful working of my invention I produce by the disruptive discharge of the accumulated energy of a condenser maintained by charging said condenser from a suitable source and discharging it into or through a circuit under proper relations of self-induction, capacity, resistance, and period in well-understood ways. Such a discharge is known to be, under proper conditions, intermittent or oscillating in character, and in this way a current varying in strength at an enormously rapid rate may be produced. Having produced in the above manner a current of excessive frequency, I obtain from it by means of an induction-coil enormously high potentials—that is to say, in the circuit through which or into which the disruptive discharge of the condenser takes place, I include the primary of a suitable induction-coil, and by a secondary coil of much longer and finer wire I convert to currents of extremely high potential. The differences in the length of the primary and secondary coils in connection with the enormously rapid rate of change in the primary current yield a secondary of enormous frequency and excessively high potential. Such currents are not, so far as I am aware, available for use in the usual ways; but I have discovered that if I connect to either of the terminals of the secondary coil or source of current of high potential the leading-in wires of such a device, for example, as an ordinary incandescent lamp, the carbon may be brought to and maintained at incandescence, or, in general, that any body capable of conducting the high-tension current described and properly enclosed in a rarefied or exhausted receiver may be rendered luminous or incandescent, either when connected directly with one terminal of the secondary source of energy or placed in the vicinity of such terminals so as to be acted upon inductively.

为了产生甚高频率和甚高电势的电流，可以使用某些众所周知的装置。例如，可以使用一个恒向电流发电机作为电流或电能的主要来源，它的电路可以通过机械装置以极快的速度中断，或者可以使用被专门构造用来产生非常小周期的交流电的磁电动机，在这两种情况下，如果电势太低，可以使用一个感应线圈来提高它；或者，最后，在这种情况下为了克服在达到最佳结果之前实际上已经变得无法克服的机械困难，可以利用破坏性放电的原理。通过后一种方案，我产生了比建议的其他方法更大的电流变化速率，在说明我的发明时，我将把产生电流的装置或设备的描述限制在这种方案中，尽管我不会被理解为限制自己使用它。因此，高频电流是成功实施我的发明所必需的，它是通过使一个电容器的累积能量进行破坏性放电而产生的，该破坏性放电是通过以下方式维持：用合适的电源对所述电容器充电，并以容易理解的方式在自感、电容、电阻和周期的适当关系下将其放电到一个电路中或通过电路放电。众所周知，在适当的条件下，这种放电在性质上是间歇的或振荡的，这样就可以产生强度变化极快的电流。以上述方式可以产生一种过高频率的电流，我通过感应线圈获得巨大的电势——也就是说，在这种电路中，电容器的破坏性放电通过这种电路或进入这种电路，我收录了一个合适的感应线圈的初级线圈和更长更细的导线绕成的次级线圈，我用这些工具把破坏性放电转换成电势极高的电流。初级线圈和次级线圈的长度差异，以及初级电流的快速变化，产生了频率极高、电位极高的次级电流。据我所知，这样的电流不能以通常的方式使用；但我已经发现，如果我将这种设备的引入导线连接到次级线圈或高电位电流源的终端，例如，作为一个普通的白炽灯，碳可以达到白炽状态并保持在白炽状态，或者，一般来说，任何能够传导所述高压电流并被适当地封闭在气体被稀薄化或被抽真空的接收器中的物体可以变得发光或白炽，这种情况也发生在或者当这种物体直接与能量的次级电源的一个终端连接时，或者放置在这些终端附近以便感应作用时。

Without attempting a detailed explanation of the causes to which this phenomenon may be ascribed, I deem it sufficient to state that, assuming the now generally accepted theories of scientists to be correct,

the effects thus produced are attributable to molecular bombardment, condenser action, and electric or etheric disturbances. Whatever part each of any of these causes may play in producing the effects noted, it is, however, a fact that a strip of carbon or a mass of any other shape, either of carbon or any more or less conducting substance in a rarefied or exhausted receiver and connected directly or inductively to a source of electrical energy such as I have described, may be maintained at incandescence if the frequency and potential of the current be sufficiently high.

在没有试图详细解释这种现象的原因的情况下,我认为它足以说明,假设现在普遍接受的科学家理论是正确的,由此产生的效应可归因于分子轰击、电容器的作用,以及电或以太的扰动。无论这些原因中的每一个可能在产生提到的效果中起什么作用,然而,一个事实是,一条碳条或任何其他形状的团块,无论是碳还是或多或少导电的物质,被放置于一个被稀薄化或被抽真空的接收器内并直接地或感应地与一个我所描述的电能源连接,如果电流的频率和电势足够高,那么它们会维持在白炽状态。

I would here state that by the terms “currents of high frequency and high potential” and similar expressions which I have used in this description I do not mean, necessarily, currents in the usual acceptance of the term but, generally speaking, electrical disturbances or effects such as would be produced in the secondary source by the action of the primary disturbance or electrical effect.

我在此声明,我在本说明书中使用的术语“高频和高电位的电流”和类似的表达,不一定是指通常接受的术语中的电流,而是,一般来说,指的是诸如由于初级的扰动或电效应的作用而在次级电源中产生的电扰动或效应。

It is necessary to observe in carrying out this invention that care must be taken to reduce to a minimum the opportunity for dissipation of the energy from the conductors intermediate to the source of current and the light-giving body. For this purpose the conductors should be free from projections and points and well covered or coated with a good insulator.

在实施本发明时,必须注意将电流源和发光体之间的导体的能量耗散的机会减到最小。为此,导体应无突起和尖端,并用良好的绝缘体很好地覆盖或涂敷。

The body to be rendered incandescent should be selected with a view to its capability of withstanding the action to which it is exposed without being rapidly destroyed, for some conductors will be much more speedily consumed than others.

选择要变成白炽的物体时,应考虑到它的能承受所暴露的作用而不被迅速破坏的能力,因为有些导体比其他导体消耗得更快。

I now refer to the accompanying drawings, in which—

我现在参考附图,其中—

Figure 1 is a diagram of one of the special arrangements that I have employed in carrying out my discovery, and Figs. 2 and 3 are vertical sectional views of modified forms of light-giving devices that I have devised for use with the system.

图 1 是我在实施我的发现时采用的一种特殊布置的示意图,图 2 和图 3 是我设计的用作该系统的发光装置的改进形式的垂直截面图。

I would state that as all of the apparatus herein shown, with the exception of certain special forms of lamp invented by me, is or may be of well-known construction and in common use for other purposes, I have indicated such well-known parts therefor by conventional representations.

我要说明的是,除了我发明的某些特殊形式的灯之外,这里所示的所有装置都是或可能是众所周知的结构,并且通常用于其他目的,因此我已经用常规的代表法表示了这些众所周知的部件。

G is the primary source of current or electrical energy. I have explained above how various forms of generators might be used for this purpose; but in the present illustration I assume that G is an alternating-current generator of comparatively low electro-motive force. Under such circumstances I raise the potential of the current by means of an induction-coil having a primary P and a secondary S. Then by the current development in this secondary I charge a condenser C, and this condenser I discharge through or into a circuit A, having an air-gap a, or, in general, means for maintaining a disruptive discharge. By the means above described a current of enormous frequency is produced. My object is next to convert this into a working-circuit of very high potential, for which purpose I connect up in the circuit A the primary P' of an induction-coil having a long fine wire secondary S'. The current in the primary P' develops in the secondary S' a current or electrical effect of corresponding frequency, but of enormous difference of potential, and the secondary S' thus becomes the source of the energy to be applied to the purpose of producing light.

G 是电流或电能的主电源。我在上面解释了各种形式的发电机如何可以用于这个目的;但在本例中,我假设 G 是一个电动势相对较低的交流发电机。在这种情况下,我通过一个具有初级 P 和次级 S 的感应线圈来提高电流的电势。然后,利用该次级线圈中电流的产生,我对电容器 C 充电,并且我让该电容器通过电路 A 放电或者放电到电路 A 中,该电路 A 具有空气间隙 a,或者一般具有用于维持破坏性放电的工具。通过上述方法,产生了一种频率巨大的电流。我的目标是下一步把这种电流转换进一个甚高电位的工作电路,为此,我在电路 A 中连接了一个感应线圈的初级 P',该线圈具有一个长细导线的次级 S'。初级 P'中的电流在次级 S'中产生一个相应频率的电流或电效应,但具有巨大的电势差,因此次级 S'成为用于产生光的能量源。

The light-giving devices may be connected to either terminal of the secondary S'. If desired, one terminal may be connected to a conducting-wall W of a room or space to be lighted and the other arranged for connection of the lamps therewith. In such case the walls should be coated with some metallic or conducting substance in order that they may have sufficient conductivity.

发光设备可以连接到次级 S'的任一终端上。如果需要,一个终端可以连接到要被照明的房间或空间的导电壁 W,而另一个终端被布置用于与灯相连接。在这种情况下,墙壁应该涂上一些金属或导电物质,以便它们具有足够的导电性。

The lamps or light-giving devices may be an ordinary incandescent lamp; but I prefer to use specially-designed lamps, examples of which I have shown in detail in the drawings. This lamp consists of a

rarefied or exhausted bulb or globe which encloses a refractory conducting body, as carbon, of comparatively small bulk and any desired shape. This body is to be connected to the secondary by one or more conductors sealed in the glass, as in ordinary lamps, or is arranged to be inductively connected thereto. For this last-named purpose the body is in electrical contact with a metallic sheet in the interior of the neck of the globe, and on the outside of said neck is a second sheet which is to be connected with the source of current. These two sheets form the armatures of a condenser, and by them the currents or potentials are developed in the light-giving body. As many lamps of this or other kinds may be connected to the terminal of S' as the energy supplied is capable of maintaining at incandescence.

灯或发光装置可以是一个普通的白炽灯；但是我更喜欢使用特别设计的灯，我已经在图中详细展示了这些灯的例子。这种灯由一个被稀薄化或抽真空的灯泡或球罩组成，该灯泡或球罩内封装了一个耐火导体，如碳，它具有相对较小的体积和任何所需的形状。该导体通过密封在玻璃中的一个或多个导体连接到次级，就像在普通灯中一样，或者被布置成感应地连接到次级。为了这个最后提到的目的，该导体与球罩颈部内部的金属片电接触，并且在所述颈部的上部是与电源连接的第二金属片。这两个薄片形成了电容器的电容极板，通过它们在发光体中产生电流或电势。只要所提供的能量能够维持在白炽状态，就可以将尽可能多的这种或其他种类的灯连接到 S' 的终端。

In Fig. 3, b is a rarefied or exhausted glass globe or receiver, in which is a body of carbon or other suitable conductor e. To this body is connected a metallic conductor f, which passes through and is sealed in the glass wall of the globe, outside of which it is united to a copper or other wire g, by means of which it is to be electrically connected to one pole or terminal of the source of current. Outside of the globe the conducting-wires are protected by a coating of insulation h, of any suitable kind, and inside the globe the supporting-wire is enclosed in and insulated by a tube or coating k of a refractory insulating substance, such as pipe-clay or the like. A reflecting-plate l is shown applied to the outside of the globe b. This form of lamp is a type of those designed for direct electrical connection with one terminal of the source of current; but, as above stated, there need not be a direct connection, for the carbon or other illuminating body may be rendered luminous by inductive action of the current thereon, and this may be brought about in several ways. The preferred form of lamp for this purpose, however, is shown in Fig. 2. In this figure the globe b is formed with a cylindrical neck, within which is a tube or sheet m of conducting material on the side and over the end of a cylinder or plug n of any suitable insulating material. The lower edges of this tube are in electrical contact with a metallic plate o, secured to the cylinder n, all the exposed surfaces of such plate and of the other conductors being carefully coated and protected by insulation. The light-giving body e, in this case a straight stem of carbon, is electrically connected with the said plate by a wire or conductor similar to the wire f, Fig. 3, which is coated in like manner with a refractory insulating material k. The neck of the globe fits into a socket composed of an insulating tube or cylinder p, with a more or less complete metallic lining s, electrically connected by a metallic head or plate r with a conductor g, that is to be attached to one pole of the source of current. The metallic lining s and the sheet m thus compose the plates or armatures of a condenser.

在图 3 中，b 是一个被稀薄化或抽真空的玻璃球罩或接收器，其中是一个碳体或其他合适的导体 e。一个金属导体 f 连接到该导体上，该金属导体 f 穿过并密封在球罩的玻璃壁中，在该玻璃壁的外部，该金属导体 f 结合到铜或其他导线 g，通过它，该金属导体 f 电连接到电流源的一个极或终端。在球罩外部，导线由任何合适种类的绝缘涂层 h 保护，而在球罩内

部，支撑导线被一种耐火绝缘材料（比如白黏土或类似物）制成的一个管子或涂层 k 密封其中并绝缘。一个反射板 l 被展示出应用于球罩 b 的外部。这种形式的灯是一种设计用于与电流源的一个终端直接电连接的灯；但是，如上所述，不需要直接连接，因为碳或其他发光体可以通过电流在其上的感应作用而发光，这可以通过几种方式实现。然而，用于此目的的灯的首选形式在图 2 中展示出。在该图中，球罩 b 形成有圆筒形颈部，在该颈部内，在任何合适的绝缘材料制成的圆柱体或塞子 n 的侧面和端部上方有导电材料的管或片 m。该管的下边缘与固定在圆筒 n 上的金属板 o 电接触，该板和其他导体的所有暴露表面都小心地涂覆绝缘层并加以保护。发光体 e，在这种情况下是直的碳杆，通过类似于图 3 中的导线 f 的导线或导体与所述板电连接，导线 f 以类似的方式涂覆有耐火绝缘材料 k。球罩的颈部安装在由一个绝缘管或圆筒 p 组成的一个插座中，该绝缘管或圆筒 p 具有或多或少完整的金属衬里 s，该衬里通过金属头或板 r 与导体 g 电连接，该导体 g 连接到电流源的一个极上。因此，金属衬里 s 和薄板 m 构成了电容器的极板或电容板。

This invention is not limited to the special means described for producing the results hereinabove set forth, for it will be seen that various plans and means of producing currents of very high frequency are known, and also means for producing very high potentials; but I have only described herein certain ways in which I have practically carried out the invention.

本发明不限于所描述的用于产生上述结果的特殊装置，因为将会看到，产生甚高频的电流的各种方案和装置是已知的，并且还包括用于产生甚高电势的装置；但是我在此仅描述了我实际实施本发明的某些方式。

What I claim is—

我主张的是—

1. The improvement in the art of electric lighting herein described, which consists in generating or producing for the operation of the lighting devices currents of enormous frequency and excessively high potential, substantially as herein described.

1、本文所述的电照明领域的改进，包括产生或生产用于照明设备运行的频率巨大和电势极高的电流，基本上如本文所述。

2. The method of producing an electric current for practical application, such as for electric lighting, which consists in generating or producing a current of enormous frequency and inducing by such current in a working circuit, or that to which the lighting devices are connected, a current of corresponding frequency and excessively high potential, as set forth.

2、产生用于实际应用的电流的方法，例如用于电力照明，该方法包括产生或生产频率巨大的电流，并且由工作电路中的这种电流或照明设备所连接的电路中的这种电流感应出相应频率和过高电势的电流，如上所述。

3. The method of producing an electric current for practical application, such as for electric lighting, which consists in charging a condenser by a given current, maintaining an intermittent or oscillatory discharge of said condenser through or into a primary circuit, and producing thereby in a secondary

working-circuit in inductive relation to the primary very high potentials, as set forth.

3、产生用于实际应用的电流的方法，例如用于电力照明，该方法包括通过一个给定电流对一个电容器充电，维持所述电容器通过或进入一个初级电路的间歇放电或振荡放电，并由此在与初级电路感应相关的次级工作电路中产生甚高电势，如上所述。

4. The method of producing electric light by incandescence by electrically or inductively connecting a conductor enclosed in a rarefied or exhausted receiver to one of the poles or terminals of a source of electric energy or current of a frequency and potential sufficiently high to render said body incandescent, as set forth.

4、一个产生电照明的方法，是通过将封闭在被稀薄化或被抽真空的接收器中的导体电连接到或感应连接到具有足够高的频率和电势的一个电极或终端上，以使所述导体白炽化，如上所述。

5. A system of electric lighting, consisting in the combination, with a source of electric energy or current of enormous frequency and excessively high potential, of an incandescent lamp or lamps consisting of a conducting body enclosed in a rarefied or exhausted receiver and connected directly or inductively to one pole or terminal of the source of energy, as set forth.

5、一种电力照明系统，由一个或多个白炽灯与一个频率巨大和电位极高的电能源或电流源组合而成，白炽灯由封闭在一个被稀薄化或被抽真空的接收器中的导体组成，并直接连接到或感应连接到能量源的一个电极或终端，如上所述。

6. In a system of electric lighting, the combination, with a source of currents of enormous frequency and excessively high potential, of incandescent lighting devices, each consisting of a conducting body enclosed in a rarefied or exhausted receiver, said conducting body being connected directly or inductively to one pole or terminal of the source of current, and a conducting body or bodies in the vicinity of said lighting devices connected to the other pole or terminal of said source, as set forth.

6、在一个电照明系统中，具有巨大频率和极高电势的电流源的白炽照明设备的组合，每个白炽照明设备由封装在被稀薄化或被抽真空的接收器中的导体组成，所述导体直接连接到或感应连接到电流源的一个极或终端，并且在所述照明设备附近的导体连接到所述源的另一个极或终端，如上所述。

7. In a system of electrical lighting, the combination, with a source of currents of enormous frequency of excessively high potential, of lighting devices, each consisting of a conducting body enclosed in a rarefied or exhausted receiver and connected by conductors directly or inductively with one of the terminals of said source, all parts of the conductors intermediate to the said source and the light-giving body being insulated and protected to prevent the dissipation of the electric energy, as herein set forth.

7、在一个电照明系统中，照明设备与频率极高或电位极高的一个电流源的组合，每个照明设备由封闭在被稀薄化或被抽真空的接收器中的导体组成，并通过导体直接或感应地与所述电源的一个终端连接，在所述电源和发光体之间的导体的所有部分被绝缘和保护，以防止电能的耗散，如本文所述。

NIKOLA TESLA.

尼古拉·特斯拉

Witnesses:

PARKER W. PAGE,

M. G. TRACY.

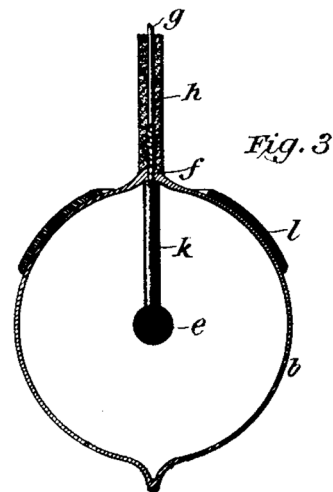
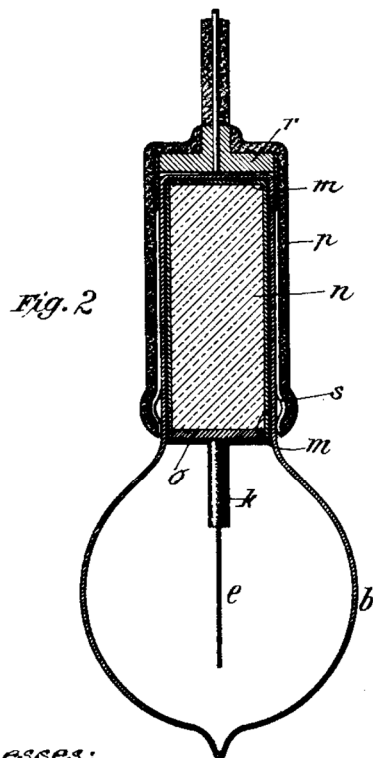
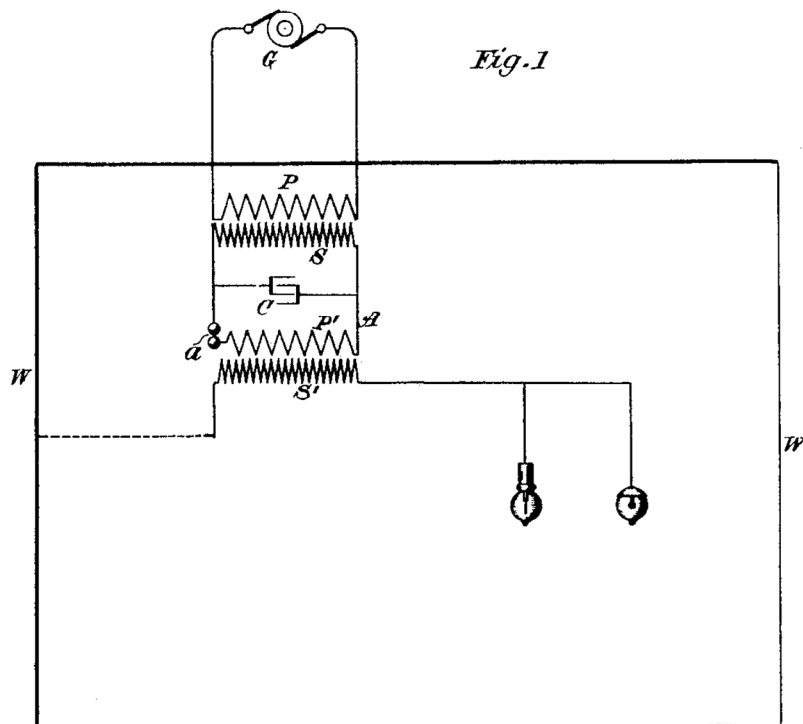
见证人：帕克·W·佩奇、M. G.特雷西。

(No Model.)

N. TESLA.
SYSTEM OF ELECTRIC LIGHTING.

No. 454,622.

Patented June 23, 1891.



Witnesses:
Raphael Netter
Ernest Hopkinson

Inventor
Nikola Tesla
by
Duncan & Page,
Attorneys.

ELECTRIC INCANDESCENT LAMP.

电力白炽灯

NIKOLA TESLA, OF NEW YORK, N. Y.

纽约州纽约市的尼古拉·特斯拉

SPECIFICATION forming part of Letters Patent No. 455,069, dated June 30, 1891.

Application filed May 14, 1891. Serial No. 392,669. (No model.)

该说明书形成了颁发于 1891 年 6 月 30 日编号为 455,069 的专利证书的一部分。

原始申请于 1891 年 5 月 14 日提交，序列号 392,669。(没有模型)

To all whom it may concern:

致所有相关人士:

Be it known that I, NIKOLA TESLA, a subject of the Emperor of Austria, from Smiljan, Lika, border country of Austria-Hungary, residing at New York, in the county and State of New York, have invented certain new and useful Improvements in Electric Incandescent Lamps, of which the following is a specification, reference being had to the accompanying drawings.

众所周知，我、尼古拉·特斯拉、奥地利皇帝的一位臣民，来自奥匈帝国边境地区的利卡县的史密里安村，并且是一位居住在纽约州纽约郡纽约市的居民，在电力白炽灯方面已经发明了某些新的有用的改进，以下是该发明一个说明书，必须参考随附的图纸。

My invention is a new form of lamp for giving light by the incandescence of carbon or other suitable refractory conductor produced by electrical energy.

我的发明是一种新形式的灯，用于利用电能通过的碳或其他合适的耐火导体的白炽来发光。

In order to more distinctly point out those features which distinguish my invention, I would state that heretofore electric lamps have been made, first, by mounting a refractory conductor on metallic supporting-wires leading into a hermetically-sealed receiver from which the air has been exhausted or replaced by an inert gas, and, second, by placing two independent conductors in a receiver or globe and partially exhausting the air therefrom. In the first case the carbon or other conductor is rendered incandescent by the actual flow or passage of a current through it, while in the second the luminous effects, as heretofore produced, or, in fact, the only luminous effects that could be produced by any means heretofore known, were due to an actual discharge of current from one conductor to the other across the intermediate space of rarefied air or gas.

为了更清楚地指出区别我的发明的那些特征，我要声明，迄今为止电灯已经被制造，第一，通过将耐火导体安装在金属支撑导线上，该金属支撑导线通向全封闭的一个接收器，空气已经从该接收器抽出或被一种惰性气体代替，第二，可以将两个独立的导体放置在一个接

收器或球罩中，并从中抽出部分空气。在第一种情况下，碳或其他导体由于流经它们的电流的实际流动或通过而变得白炽，而在第二种情况下，迄今为止产生的发光效果，或者事实上，利用迄今为止已知的任何方法可以产生的唯一发光效果，是由于电流从一个导体穿过稀薄空气或气体的中间空间到达另一个导体的实际放电。

It may be further remarked that in various forms of Geissler or vacuum tubes the terminals or points within the tube become or have a tendency to become heated by the action of the high-tension secondary discharge. In such tubes, however, the degree of exhaustion is comparatively low, as a high vacuum prevents the well-known Geissler discharge or effect. Moreover, with such low degrees of exhaustion the points or wires, if heated and allowed to become incandescent, are speedily destroyed.

还可以进一步指出，在各种形式的盖斯勒管或真空管中，管内的终端或尖端由于高压次级放电的作用而变热或有变热的趋势。然而，在这种管中，抽真空程度相对较低，因为一个高真空防止了众所周知的盖斯勒放电或效应。此外，如此低的抽真空程度，尖端或导线，如果被加热并允许成为白炽，会被迅速摧毁。

I have discovered that two conducting-bodies mounted in a very highly exhausted receiver may be rendered incandescent and practically utilized as a source of light if connected directly or inductively to the terminals of a source of current of very great frequency and very high potential.

我已经发现，如果直接地或感应地连接到甚高频和甚高电势的电流源的终端上，安装在高度真空的接收器中的两个导体可以变成白炽的，并且实际上可用作光源。

The practical requirements of this invention are widely different from those employed in producing any of the phenomena heretofore observed, such differences being mainly in respect to the current, which must be one of enormous frequency and of excessively high potential, and also to the degree of exhaustion of the globe or receiver, which must be carried at least beyond the point at which a spark will pass, or to the condition known as a “non-striking vacuum,” and it may be as much farther as possible.

本发明的实际要求与以前观察到的产生任何现象所采用的要求有很大的不同，这种不同主要是关于电流，它必须频率巨大且电势极高，也是关于球罩或接收器的抽真空程度，它必须至少超过火花将通过的程度点，或者达到被称为“非显著真空”的条件，并且真空程度可能越高越好。

This application is confined to a particular form of lamp which I employ in a new system invented by me, which system involves, as one of its essential characteristics, the employment of currents or electric effects of a novel kind. In an application filed by me April 25, 1891, No. 390,414, I have shown and described this system in detail, and I therefore deem it sufficient for the present case to say that the lamps herein described, while utterly inoperative on any of the circuits now, or, so far as I am aware, heretofore employed become highly efficient sources of light if the frequency of the current by which they are operated be sufficiently great and the potential sufficiently high. To produce such currents, any known means may be utilized or the plan described in my said application followed of disruptively discharging the accumulated energy in a condenser into or through a primary circuit to produce a current of very high frequency, and inducing from this current a secondary current of a very much

higher potential.

这种应用仅限于我在自己发明的新系统中使用的一种特殊形式的灯,该系统的基本特征之一是使用了一种新颖的电流或电效应。在我于 1891 年 4 月 25 日提交的第 390,414 号申请中,我已经详细地展示和描述了这个系统,因此我认为对于目前的情况来说,足以说这里描述的灯,虽然现在在任何电路上完全不起作用,或者,据我所知,迄今为止如果运行电路的电流的频率足够大并且电势足够高,那么所使用的灯将成为高效的光源。为了产生这样的电流,可以使用任何已知的工具,或者在我的所述申请中所描述的方案,将电容器中积累的能量破坏性地释放到初级电路中或者通过初级电路释放,以产生一种具有非常高频率的电流,并且从该电流中感应出一种电势高得多的次级电流。

I now refer to the drawings in illustration of the invention.

我现在参考附图来说明本发明。

Figure 1 is a vertical sectional view of a lamp constructed with leading-in wires for direct connection with a circuit or source of current. Fig. 2 is a similar view of a form of lamp arranged for inductive connection with such source.

图 1 是灯的一个垂直剖视图,该灯由引入导线构成,用于与一个电路或电流源直接连接。图 2 是与这种电源感应连接的一种灯的类型视图。

The common methods or steps followed in the manufacture of the ordinary incandescent lamps and Geissler tubes may be employed in the manufacture of these improved lamps as far as applicable.

只要适用,在制造普通白炽灯和盖斯勒管中遵循的普通方法或步骤可以用于制造这些改进的灯。

A is a glass globe or receiver with a neck or base B. Conducting-wires C C enter this globe and are sealed in the walls thereof. The entering wires C are surrounded by small tubes or cups D. The joints between the wires C and the incandescing conductors are made within these cups in any ordinary manner, and the lower parts of the cups are filled with bronze-powder E or other suitable material to effect a good electrical connection. The cups are then filled up with fire-clay or other refractory non-conductor F, which is molded around the carbons G. The carbons or other refractory conductors or semi-conductors G are completely isolated from one another. They are here shown as slender strips; but they may have any other desired shape. Lamps thus made are attached to a vacuum-pump in the usual way. After the process of exhaustion has been carried on for some time they are brought to incandescence by a suitable current, by which the fire-clay is thoroughly baked and the occluded gases are driven off. The exhaustion is carried to the highest possible point, and the globe finally sealed off at H. Inasmuch as there is a tendency to sparking when the current is turned on before the exhaustion has been carried very high, it is well, when the character of the carbon admits of it, to cause their ends to approach, in order that the sparks may leap across between such points, whereby the danger of injury to the carbons or the lamp is lessened. The conductors outside the globe, as well as all those which convey the current from the source, should be carefully insulated to prevent the dissipation of the current.

A 是一个带有颈部或基座 B 的玻璃球或接收器。导线 C C 进入这个球罩并被密封在罩壁中。进入的导线 C 被小管或小杯 D 包围。导线 C 和白炽导体之间的接头以任何普通的方式在这些杯中形成，杯的下部填充青铜粉 E 或其它合适的材料以实现良好的电连接。然后用耐火粘土或其他难熔的非导体 F 填充这些杯子，并在碳 G 周围成型。碳或其他耐高温导体或半导体 G 彼此完全隔离。它们在这里显示为细长的条带；但是它们可以具有任何其他期望的形状。这样制成的灯以通常的方式连接到一个真空泵上。抽真空的过程进行了一段时间后，它们被一个合适的电流带到白炽状态，通过这种电流，耐火粘土被彻底烘烤，封闭的气体被赶走。抽真空被带到了尽可能的最高程度，球罩最终在 H 点被封闭。因为有一种倾向，就是当在抽真空被带到了很高的程度前，打开电流进行火花放电，这是很好的，当碳的特性允许这一点，这导致它们的末端接近，是为了火花可能在这些点之间跳跃，从而减少伤害碳或灯的危险。球罩外面的导体，以及所有从电源输送电流的导体，都应该被仔细绝缘，以防止电流耗散。

In lieu of connecting the two carbons directly to the circuit through leading-in wires, provision may be made for inductively connecting them, as by means of condensers. Fig. 2 shows a form of lamp of this description that I have employed. The globe A has two extended tubular portions B B'. Inside of these tubular extensions are condenser-coatings K K'.

代替通过引入线将两个碳直接连接到电路，可以提供感应地连接它们，例如利用电容器。图 2 展示了我已经采用的这种灯的一种形式。球罩 A 具有两个延伸的管状部分 B B'。这些管状延伸部分的内部是电容器涂层 K K'。

J J are plugs of fire-clay or the like contained in the extensions B B'. The two conductors G G are supported by these plugs and connected by metallic strips M with the condenser-coatings K K', respectively. Over the outside of the extensions B B' are fitted insulating-caps N N', having metallic linings O O', with terminals adapted for connection with the circuit-wires. With such currents as are employed to operate these lamps condensers of small capacity, such as those thus made, transmit the energy from the outside circuit to the carbons within the globe with little loss. This lamp is exhausted and sealed off from the pump in the same manner as that first described. There is no electrical connection at any time between the two carbons of this lamp and no visible discharge or transfer of current from one to the other through the highly-rarefied medium between them. The fact, therefore, of their being rendered incandescent by the action of such a current as I have described seems to be mainly attributable to condenser action.

J J 是被包含在延伸部分 B B' 中的由耐火粘土或类似物制成的塞子。两个导体 G G 由这些塞子支撑，并通过金属条 M 分别与电容器涂层 K K' 连接。在延伸部分 B B' 的外侧安装绝缘帽 N N'，绝缘帽具有金属衬里 O O'，具有适合与电路导线连接的终端。使用这样的电流来操作这些小容量的电灯电容器，例如这样制造的那些电容器，将能量从外部电路传输到球罩内部的碳，几乎没有能量损失。该灯以与第一次描述的方式相同的方式被抽真空并从泵那里密封。该灯的两块碳之间在任何时候都没有电连接，并且也没有通过它们之间的高度稀薄的介质来实现从一个碳到另一个碳的可见的放电或电流转移。事实上，因此，它们在我所描述的这种电流的作用下呈现白炽的事实似乎主要归因于电容器的作用。

The carbons, or whatever substance may be used in their stead, may be of any desired form and may be placed in different relative positions.

碳或任何可以代替它们的物质可以是任何期望的形式，并且可以放置在不同的相对位置。

The manner of making the lamp and the general form of the lamp as a whole may be varied in numberless ways. I have merely shown herein typical forms which embody the principle of the invention and which by experience I have demonstrated to be practical lamps.

制造灯的方式和灯的总体形式可以以无数种方式变化。我在此仅展示出了体现本发明原理的典型形式，我已经通过经验证明了这些形式是实用的灯。

As the lamps which I employ and which are made as above described are absolutely inoperative in any system from which the hereinbefore-described conditions of potential and frequency are absent, so the various lamps heretofore devised for use with high-potential currents, in which the exhaustion, of necessity, has not been carried to or beyond the non-striking point, are practically worthless in my new system, and this is the distinguishing feature of novelty in my lamps—viz., that they are exhausted to or beyond the non-striking point.

由于我使用的灯和如上所述制造的灯在任何没有上述电势和频率条件的系统中是绝对不起作用的，所以迄今为止设计的用于高电势电流的各种灯，其中必然的抽真空没有达到或超过非显著点，实际上在我的新系统中是没有价值的，这是我的灯的新颖性的显著特征——也就是它们要被抽真空到或超过非显著真空点。

What I claim as my invention is—

我主张我的发明是—

1. An incandescent lamp consisting of two isolated refractory conductors contained in a non-striking vacuum and adapted to produce light by incandescence, each being provided with a terminal for connection with a source of electrical energy, as set forth.

1、一种白炽灯，由两个被包含在非显著真空中的彼此隔离的耐火导体组成，适于通过白炽发光，每个导体都有一个与电源连接的终端，如上所述。

2. The combination, with a globe or receiver exhausted to the non-striking point, of two isolated bodies of refractory conducting material adapted to emit light by incandescence and mounted within said globe, and means for connecting said bodies with the two poles or terminals, respectively, of a source of electrical energy.

2、一种组合，它包括一个球罩或接收器，被抽真空到非显著真空；还包括两个彼此隔离的耐火导电材料，适于通过白炽而发光并被安装在所述球罩内；以及将发光导体与一个电能源两极或两个终端分别连接的工具。

3. In an incandescent electric lamp, the combination, with a globe or receiver exhausted to the non-striking point, of metallic wires sealed therein, a refractory body mounted on or electrically connected to each wire, the said wires within the globe and such parts of the refractory body as are not to be rendered incandescent being coated or covered with insulation, as set forth.

3、在一种白炽电灯中，存在一个组合，它包括被抽真空到非显著点的一个球罩或接收器；被密封在其中的金属线；安装在每条导线上或与其电连接的耐火体；其中球罩内的所述线和耐火体的不呈现白炽的部分被涂覆或覆盖有绝缘材料，如上所述。

4. The combination, with a globe or receiver exhausted to the non-striking point, of metallic wires sealed therein, a refractory conductor united to each of said wires within the globe, an insulating-covering around the wires and joint, and a refractory insulating-body surrounding the refractory conductors near the joint, as set forth.

4、存在一个组合，它包括一种球罩或者接收器，被抽真空到非显著点；被密封在其中的金属导线；结合到球罩内的每根所述导线的一个耐火导体；围绕导线和接头的一种绝缘涂覆层；以及在接头附近围绕耐火导体的耐火绝缘体，如上所述。

NIKOLA TESLA.

尼古拉·特斯拉

Witnesses:

ROBT. F. GAYLORD,

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见证人:

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(No Model.)

N. TESLA.
ELECTRIC INCANDESCENT LAMP.

No. 455,069.

Patented June 30, 1891.

Fig. 1

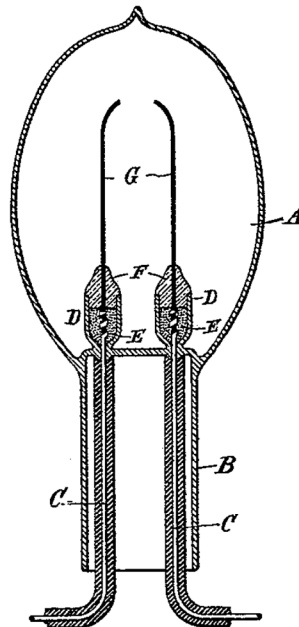
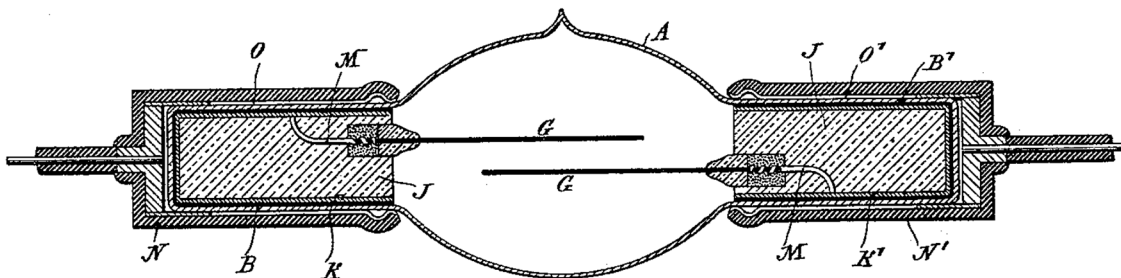


Fig. 2



Witnesses:
Raphael Netter
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Nikola Tesla
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INCANDESCENT ELECTRIC LIGHT.

白炽电灯

NIKOLA TESLA, OF NEW YORK, N. Y.

纽约州纽约市的尼古拉·特斯拉

SPECIFICATION forming part of Letters Patent No. 514,170, dated February 6, 1894.

Application filed January 2, 1892. Renewed December 15, 1893. Serial No. 493,776. (No model.)

该说明书形成了颁发于 1894 年 2 月 6 日编号为 514,170 的专利证书的一部分。

申请于 1892 年 1 月 2 日提交，更新于 1893 年 12 月 15 日。序列号为 493,776。（没有模型）

To all whom it may concern:

致所有相关人士:

Be it known that I, NIKOLA TESLA, a citizen of the United States, residing at New York, in the county and State of New York, have invented a certain new and useful Improvement in Incandescent Electric Lamps, of which the following is a specification, reference being had to the drawings accompanying and forming a part of the same.

众所周知，我、尼古拉·特斯拉、一名美国公民，居住在纽约州纽约郡纽约市的曼哈顿区，在白炽电灯方面已经发明了某些新的和有用的改进，以下是该发明一个说明书，必须参考随附的图纸，它已形成了该说明书的一部分。。

This invention is an improvement in the particular class of electric lamps or lighting devices invented by me and for which I have heretofore obtained Letters Patent, notably No. 454,622, dated June 23, 1891.

本发明是对我发明的电灯或照明装置这一特殊类别的改进，迄今为止，我已经获得了该类电灯或照明装置的专利证书，特别是在 1891 年 6 月 23 日被授予的第 454,622 号专利。

The invention applies more particularly to that form of lamp in which a small body or button of refractory material is supported by a conductor entering a very highly exhausted globe or receiver, but is also applicable generally to other forms of lamp adapted for use with similar systems in which currents of very high potential and great frequency are employed. I have found in the practical applications of this system that a considerable dissipation of energy takes place from the conductors conveying the currents of great potential and frequency, even when such conductors are thoroughly insulated both within and without the lamp globes, and the subject of my present invention is a means for preventing such dissipation within the lamp, or rather for confining it to the particular parts or part of the conductor which is designed to give light. This object I find I may readily accomplish by surrounding the leading-in and supporting conductors with a conductor which acts as a static screen. By this means the light-giving body or button which lies beyond the influence of the screen is quickly and efficiently

brought to and maintained at higher incandescence by a suitable electrical current or effect, by reason of the fact that the electrical action to which the incandescence is due is confined mainly to the button.

本发明更具体地应用于这种类型的灯,这种灯中耐火材料的小物体或纽扣由进入高度抽真空球罩或接收器的导体支撑,但是本发明通常也可应用于适合与类似系统一起使用的其他类型的灯,在这些系统中采用了非常高的电势和频率的电流。我已经在该系统的实际应用中发现,即使当这种导体在灯泡内部和外部都完全绝缘时,传送高电势和高频率的电流的导体也会发生相当大的能量耗散,并且我的发明的主题是一种用于防止灯内产生这种耗散的工具,或者更确切地说,用于将其限制在被设计为发光导体的特定的一个或多个部分。我发现我可以很容易地完成这个目标,方法是使用充当一个静电屏蔽的一个导体去围绕引入导线和支撑导体。通过这种方式,位于屏蔽影响范围之外的发光体或纽扣通过合适的电流或效应快速有效地达到并保持在较高的白炽度,因为引起白炽度的电作用主要局限于纽扣。

注:文中的纽扣主要指的是小球形或纽扣形耐火材料。

A description of the ordinary form of lamp which I employ will serve to illustrate the principle and nature of this improvement, and for such description I now refer to the drawings which show such lamp in central vertical section.

我所使用的普通形式的灯的一个描述将用于说明这种改进的原理和性质,并且对于这种描述,我现在参考在中央垂直截面中展示出的这种灯的附图。

A is a glass globe of the usual form, in the base of which is sealed a very thin conducting wire B, passing up through a stem of glass or other refractory insulator C. To the upper or inner end of this wire is united, as by means of a mass of carbon paste D, a carbon or other refractory stem E, that supports or carries a small button of carbon or other suitable substance F. Over the stem C is passed, at any convenient stage in the manufacture of the lamp and in any well understood way, a metallic tube G. I prefer to use for this purpose a very thin cylinder or tube of aluminum and it should entirely surround all parts of the conductor within the globe except the button itself, extending to or nearly up to the point of union of the stem E with the button F. Such a device by reason of its electrostatic action reduces the loss of energy supplied to that bulb, preventing its radiation or dissipation into space except through the exposed or unprotected button. The tube or screen G is entirely insulated from the conductors within the globe and from all external conductors or bodies. The globe, by means of a suitable air pump, is exhausted to as high a degree as practicable, or until a non-striking vacuum is attained. It is connected with the pump by the usual tube which is sealed off at K.

A 是通常形式的一个玻璃球罩,在底部密封一根非常细的导线 B,该导线穿过一个玻璃杆或其他耐火绝缘体 C。该导线的上端或内端与一团碳膏 D 和一种碳质或其他耐火材料杆 E 相结合,该杆支撑或承载碳质或其他合适物质的小纽扣 F。在灯的制造过程中,在任何方便的阶段,以任何容易理解的方式,杆 C 穿过一个金属管 G。为此,我更喜欢使用一个非常薄的铝制圆筒或管子,它应该完全包围除了纽扣本身以外的导体的所有部分,延伸到或几乎达到杆 E 与纽扣 F 的连接点。这种装置由于其静电作用而减少了提供给灯泡的能量的损失,防止能量辐射或消散到空间中,除非通过暴露的或未受保护的纽扣。管或屏蔽 G 与球罩内部的导体以及所有外部导体或物体完全绝缘。通过一个合适的空气泵,球罩被抽真空尽可能高的程度,或者直到获得一个非显著真空。它通过通常的管子与泵相连,管子在 K 处密封。

The lamp may be made in different forms and in different ways, and the invention, as may be readily understood from its above described nature and purpose, is not confined to the specific form of lamp herein shown.

这种灯可以以不同的形式和以不同的方式制造,并且从以上描述的性质和目的可以容易地理解,本发明不限于这里所展示的灯的特定形式。

What I claim is—

我主张的是—

1. In an incandescent electric lamp, the combination of an exhausted globe, a refractory light-giving body therein, a conductor leading into the globe and connected to or supporting the said body, and a conducting screen surrounding the said conductor, as set forth.

1、在一个白炽电灯中,存在一个组合,它包括被抽真空的一个球罩;该球罩中的一个耐火发光体;引入球罩并连接或支撑所述发光体的一个导体;以及包围所述导体的一个导电屏蔽,如上所述。

2. In an incandescent electric lamp, the combination of an exhausted globe, a refractory light-giving body or button therein, a conducting support for said button within the globe, and a metallic tube surrounding or enclosing the said conductor up to the point of union with the button, as set forth.

2、在一个白炽电灯中,存在一个组合,它包括被抽真空的一个球罩;该球罩中的一个耐火发光体或纽扣;球罩中所述纽扣的导电支架;以及包围或封闭所述导体直到与纽扣结合的点的金属管,如上所述。

3. In an incandescent electric lamp, the combination of an exhausted globe, a wire sealed therein, and coated with or embedded in a glass stem, a carbon stem united with the wire, a refractory conductor mounted on said stem, and a conducting tube or cylinder surrounding the wire and carbon stem, as and for the purpose set forth.

3、在一个白炽电灯中,存在一个组合,它包括被抽真空的一个球罩;密封在其中的被涂覆或嵌入一根玻璃杆的一根导线;与导线结合的一根碳杆;安装在所述碳杆上的一个难熔导体;以及围绕导线和碳杆的一个导电管或圆筒,用于所述目的。

NIKOLA TESLA.

尼古拉·特斯拉

Witnesses:

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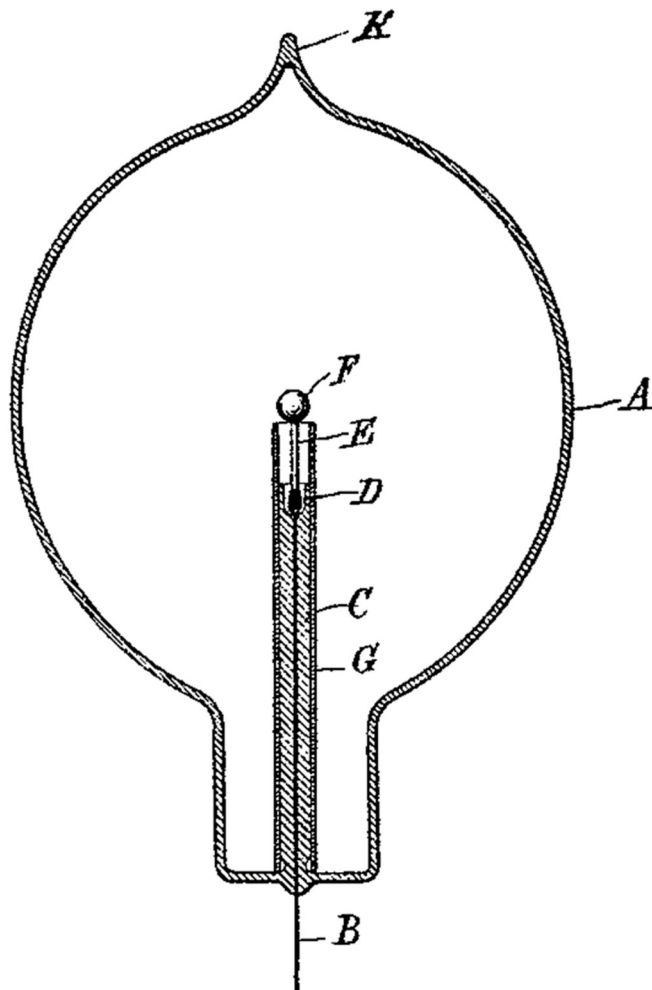
欧内斯特·霍普金森、帕克·W·佩奇。

(No Model.)

N. TESLA.
INCANDESCENT ELECTRIC LIGHT.

No. 514,170.

Patented Feb. 6, 1894.



Witnesses:

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IMPROVEMENTS IN METHODS
OF AND APPARATUS FOR THE
GENERATION OF ELECTRIC CURRENTS
OF DEFINED PERIOD

产生规定周期电流的方法的改进
和用于产生该电流的装置

No 2812 A.D. 1894
(Under International Convention.)

编号 2812 公元 1894 年
(根据国际公约。)

Date claimed for Patent under Sect 103 of Act, being date of first Foreign Application (in United States), - 19th Aug., 1893
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在 1894 年 2 月 8 日留下完整的说明书，在 1894 年 3 月 10 日被接受。

COMPLETE SPECIFICATION.
完整说明

I, Nikola Tesla, of 35 South Fifth Avenue, New York, County and State of New York, United States of America, Electrician, do hereby declare the nature of this invention, and in what manner the same is to be performed to be particularly described and ascertained in and by the following statement:-

我、尼古拉·特斯拉，住在美国纽约州纽约郡南第五大道 35 号，是一名电气技师，特此声明本发明的性质，以及以何种方式实施本发明，并在以下声明中具体描述和说明:-

This invention consists in producing electric currents of constant period by means of an engine and an electrical generator which are so constructed and related that (a), the engine of itself is capable of imparting to the moving element of the generator an oscillation of constant period, or (b) the period of reciprocation of the engine and the natural rate of vibration of the electric system will so nearly approximate as to act in resonance, or, (c), the engine, while fully capable of maintaining a vibration once started has not the power to change its rate so that the electric system will entirely control its

period.

本发明包括利用一个发动机和发电机来产生周期恒定的电流,该发动机和发电机的构造和关系使得(a)发动机本身能够向发电机的运动组件传递恒定周期的振荡,或者(b)发动机的往复运动周期和电力系统的自然振动速率将非常接近以产生共振作用,或者(c)发动机,虽然完全能够维持一个振动,但振动一旦开始,发动机就没有能力改变自身速率,因此电力系统将完全控制该振动的周期。

A description of the engine proper which has the property of running with a constant period is necessary to a complete understanding of the present invention. The following conditions are to be observed in order to produce such an engine.

对具有以一个恒定周期运行的发动机本身的描述对于完整理解本发明是必要的。为了生产这种发动机,必须遵守以下条件。

It is a well known mechanical principle that if a spring possessing a sensible inertia be brought under tension, as by being stretched, and then freed, it will perform vibrations which are isochronous, and, as to period, in the main, dependent upon the rigidity of the spring, and its own inertia or that of the system of which it may form an immediate part. This is known to be true in all cases where the force which tends to bring the spring or movable system into a given position is proportionate to the displacement.

一个众所周知的机械原理是,如果一个弹簧拥有一个敏感的惯性,在拉力下被拉伸,然后释放,那么它将执行等时振动,至于周期,主要取决于弹簧的刚度,以及它自己的惯性或系统的可以构成一个直接部分的惯性。众所周知,在倾向于将弹簧或可移动的系统带到给定位置的力与位移成正比的所有情况下,这都是正确的。

In the construction of the engine above referred to this principle is followed, that is to say, a cylinder and a piston are used one or both of which in any suitable manner are maintained in reciprocation by steam or gas under pressure.

在上述发动机的结构中,遵循了这一原理,也就是说,使用一个气缸和一个活塞中的一者或两者通过压力下的蒸汽或气体以任何合适的方式保持往复运动。

To the moving piston or to the cylinder in case the latter reciprocate and the piston remain stationary, a spring is connected so as to be maintained in vibration thereby, and whatever may be the inertia of the piston or of the moving system and the rigidity of the spring relatively to each other, provided the practical limits within which the law holds true that the forces which tend to bring the moving system to a given position are proportionate to the displacement, are not exceeded, the impulses of the power impelled piston and the natural vibrations of the spring will always correspond in direction and coincide in time.

在活塞往复运动且活塞保持静止的情况下,弹簧连接到运动的活塞或气缸,从而保持振动,无论活塞或运动系统的惯性以及弹簧相对于彼此的刚度如何,只要不超过实际极限,在该限度内,规律成立,趋向于将运动系统带到给定位置的力与位移成正比,动力推动活塞的脉冲

和弹簧的自然振动将总是在方向上一致，在时间上重合。

In the case of the engine referred to, the parts are so arranged that the movement of the piston within the cylinder in either direction ceases when the force tending to impel it and the momentum which it has acquired are counterbalanced by the increasing pressure of the steam or compressed air in that end of the cylinder towards which it is moving, and as in its movement the piston has shut off, at a given point, the pressure that impelled it established the pressure that tends to return it, it is then impelled in the opposite direction, and this action is continued as long as the requisite pressure is applied. The length of the stroke will vary with the pressure, but the rate or period of reciprocation is no more dependent upon the pressure applied to drive the piston, than would be the period of oscillation of, a pendulum permanently maintained in vibration, upon the force which periodically impels it, the effect of variations in such force being merely to produce corresponding variations in the length of stroke or amplitude of vibration respectively.

在所提及的发动机的情况下，部件被如此布置，使得当倾向于推动活塞的力和活塞已获得的动量被活塞正在移动朝向的气缸端部中的蒸汽或压缩空气的正在增加的压力所抵消时，活塞在气缸内的任一方向上的运动将停止，并且当活塞在运动中停止在给定点时，推动它的压力建立了倾向于退回它的压力，然后它被推向相反的方向，只要必要的压力被施加，这个动作将继续。冲程的长度将随压力而变化，但是往复运动的速率或周期不再取决于驱动活塞所施加的压力，而是取决于永久保持振动的摆锤的振荡周期，取决于周期性推动它的力，这种力的变化的影响仅仅是分别产生冲程长度或振动幅度的相应变化。

In practice I have found that the best results are secured by the employment of an air spring, that is, a body of confined air or gas which is compressed and rarefied by the movements of the piston, and in order to secure a spring of constant rigidity I prefer to employ a separate chamber or cylinder containing air at the normal atmospheric pressure, although it might be at any other pressure, and in which works a plunger connected with or carried by the piston rod. The main reason why no engine heretofore has been capable of producing results of this nature is that it has been customary to connect with the reciprocating parts a heavy flywheel or some equivalent rotary system of relatively very great inertia, or in other cases where no rotary system was employed, as in certain reciprocating engines or tools, no regard has been paid to the obtainment of the conditions essential to the end which I have in view, nor would the presence of such conditions in said devices appear to result in any special advantage.

在实践中，我发现最好的结果是通过使用空气弹簧来确保的，即利用活塞的运动来压缩和稀薄化被封闭的空气或气体，以确保弹簧的恒定刚性，我更喜欢使用一个单独的腔室或气缸，其中容纳了正常大气压下的空气，尽管它可以处于任何其他压力下，并且在其中工作的柱塞与活塞杆连接到活塞杆或由活塞杆携带。迄今为止，没有发动机能够产生这种性质的结果的主要原因是，习惯上将重型飞轮或一些惯性相对较大的等效旋转系统与往复运动部件连接，或者在没有使用旋转系统的其他情况下，如在某些往复运动发动机或工具中，没有考虑获得我所考虑的目的所必需的条件，在所述设备中存在这些条件似乎也不会产生任何特定优势。

Such an engine as I have described affords a means of accomplishing a result heretofore unattained, the continued production of electric currents of constant period, by imparting the movements of the piston to a core or coil in a magnetic field.

我所描述的这种发动机提供了一种手段来实现迄今为止未实现的一种结果, 通过将活塞的运动传递给磁场中的一个铁芯或一个线圈, 持续产生恒定周期的电流。

It should be stated, however, that in applying the engine for this purpose certain conditions are encountered which should be taken into consideration in order to satisfactorily secure the desired result. When a conductor is moved in a magnetic field and a current caused to circulate therein, the electro-magnetic reaction between it and the field, might disturb the mechanical oscillation to such an extent as to throw it out of isochronism. This, for instance, might occur when the electromagnet reaction is very great in comparison to the power of the engine, and there is a retardation of the current so that the electro-magnetic reaction might have an effect similar to that which would result from a variation of the tension of the spring but, if the circuit of the generator be so adjusted that the phases of the electromotive force and current coincide in time, that is to say, when the current is not retarded then the generator driven by the engine acts merely as a frictional resistance and will not, as a rule, alter the period of the mechanical vibration, although it may vary its amplitude. This condition may be readily secured by properly proportioning the self-induction and capacity of the circuit including the generator.

然而, 应该指出的是, 在为此目的应用发动机时, 会遇到某些情况, 为了令人满意地确保预期的结果, 应该考虑这些情况。当一个导体在磁场中运动并且电流在该导体中循环时, 导体和磁场之间的电磁反作用可能会干扰机械振荡, 使其脱离等时振荡。例如, 当电磁反作用与发动机的功率相比非常大时, 这可能发生, 并且存在电流的延迟, 使得电磁反作用可能具有类似于由弹簧拉力的变化所产生的效果, 但是, 如果发电机的电路被如此调节, 使得电动势和电流的相位在时间上重合, 也就是说, 当电流不被阻滞时, 由发动机驱动的发电机仅起摩擦阻力的作用, 尽管它可以改变机械振动的振幅, 但通常不会改变机械振动的周期。通过适当地调整包括发电机在内的电路的自感应和电容量, 可以很容易地确保这种情况。

I have, however, observed the further fact in connection with the use of such engines as a means for running a generator, that it is advantageous that the period of the engine and the natural period of electrical vibration of the generator should be the same, as in such case the best conditions for electric resonance are established and the possibility of disturbing the period of mechanical vibrations is reduced to a minimum. So much so that I have found that even if the theoretical conditions necessary for maintaining a constant period in the engine itself are not exactly maintained, still the engine and generator combined will vibrate at a constant period. For example, if instead of using in the engine an independent cylinder and plunger as an air spring of practically constant rigidity, I cause the piston to impinge upon air cushions at the ends of its own cylinder, although the rigidity of such cushions or springs might be considerably affected and varied by the variations of pressure within the cylinder, still by combining with such an engine a generator which has a period of its own approximately that of the engine, constant vibration may be maintained even through a considerable range of varying pressure, owing to the controlling action of the electro-magnetic system.

然而, 我已经观察到与将这样的发动机作为一个工具来运行一个发电机的用法有关的进一步事实, 即发动机的周期和发电机的电振动的自然周期应该相同是有利的, 因为在这种情况下, 建立了电共振的最佳条件, 并且干扰机械振动周期的可能性降低到最小。以至于我发现, 即使发动机本身保持一个恒定周期所必需的理论条件不能精确地保持, 发动机和发电机组合在一起仍然会以恒定的周期振动。例如, 如果不在发动机中使用独立的气缸和柱塞作为实际上具有恒定刚度的空气弹簧, 而是用活塞撞击其气缸端部的气垫, 尽管这种气垫或弹簧的刚度

可能会受到气缸内的压力变化显著地影响和改变,但仍然通过将这种发动机与一个发电机相结合(该发电机有与该发动机的周期相近的一个周期),由于电磁系统的控制作用,即使在相当大的压力变化范围内,也可以保持恒定的振动。

I have even found that under certain conditions the influence of the electro-magnetic system may be made so great as to entirely control the period of the mechanical vibration within wide limits of varying pressure.

我甚至发现,在某些条件下,电磁系统的影响可能如此之大,以至于在变化压力的宽限度范围内完全控制机械振动的周期。

This is likely to occur in those instances where the power of the engine while fully capable of maintaining a vibration once started, is not sufficient to change its rate.

这很可能发生在发动机功率虽然完全能够在一启动后保持振动但不足以改变其速度的情况下。

So, for sake of illustration, if a pendulum is started in vibration, and a small force applied periodically in the proper direction to maintain it in motion, this force would have no substantial control over the period of the oscillation unless the inertia of the pendulum be small in comparison to the impelling force, and this would be true no matter through what fraction of the period the force may be applied.

因此,为了说明,如果一个摆锤开始振动,一个小的力被周期性地施加在正确的方向上以保持它的运动,这个力将不会对振荡的周期有实质性的控制,除非钟摆的惯性与推动力相比是小的,不管在这个周期的哪一小段施加这个力,事实都将是这样。

In the case under consideration the engine is merely an agent for maintaining the vibration once started, although it will be understood that this does not preclude the performance of useful work which would simply result in a shortening of the stroke.

在所考虑的情况下,发动机仅仅是用于在一启动后保持振动的作用因素,尽管应该理解这并不妨碍将简单地导致冲程缩短的有用功的执行。

My invention, therefore, involves the combination of a piston free to reciprocate under the influence of a steam or a gas under pressure and the movable element of an electric generator which is in direct mechanical connection with the piston, and it is, more especially the object of my invention to secure from such combination electric currents of a constant period. In the attainment of this object I have found it is preferable to construct the engine so that it of itself controls the period, but as I have stated before, I may so modify the elements of the combination that the electro-magnetic system may exert a partial or even complete control of the period.

因此,我的发明包括在处于压力下的蒸汽的或气体的影响下,自由往复运动的活塞和与活塞直接机械连接的发电机的可移动组件的组合,并且更具体地说,我的发明旨在从这种组合中获得一个恒定周期的电流。为了达到这个目的,我发现最好这样构建发动机,使它自己控制周期,但正如我以前说过的,我可以修改该组合的组件,电磁系统可以部分地甚至完全控制

周期。

In illustration of the manner in which the invention is carried out I now refer to the accompanying drawings:

为了说明实施本发明的方式，我现在参考附图：

Fig. 1 is a central sectional view of an engine and generator embodying the invention.

图 1 是体现本发明的发动机和发电机的中心截面图。

Fig. 2 is a modification of the same.

图 2 是对该截面图的一个修改。

Referring to Figure 1, A is the main cylinder in which works a piston B. Inlet ports C C pass through the sides of the cylinder opening at the middle portion thereof and on opposite sides.

参照图 1，A 是主气缸，活塞 B 在其中工作。进气口 C C 穿过气缸中部的并且位于气缸对侧的开孔。

Exhaust ports D D extend through the walls of the cylinder and are formed with branches that open into the interior of the cylinder on each side of the inlet ports and on opposite sides of the cylinder.

排气口 D D 延伸穿过气缸壁，并在进气口的每一侧和气缸的对侧形成有通向气缸内部的支路。

The piston B is formed with two circumferential grooves E F which communicate through openings G in the piston with the cylinder on opposite sides of said piston respectively.

活塞 B 形成有两个圆周凹槽 E F，它们通过活塞中的开口 G 分别与所述活塞对侧的气缸连通。

The particular construction of the cylinder, the piston and the valves for controlling it may be very much varied, and it is not in itself material, except that in the special case now under consideration it is desirable that all the ports, and more especially the exhaust ports should be made very much larger than is usually the case so that no force due to the action of the steam or compressed air will tend to retard or affect the return of the piston in either direction.

气缸的、活塞的和用于控制活塞的阀的具体结构可以有很大的变化，其材料本身并不重要，除了在现在考虑的特殊情况下，希望所有的气口，尤其是排气口应该比通常的情况大得多，这样就不会由于蒸汽或压缩空气的作用而产生倾向于阻碍或影响活塞在任一方向上返回的力。

The piston B is secured to a piston rod H which works in suitable stuffing boxes in the heads of the

cylinder A.

活塞 B 被固定在一个活塞杆 H 上，活塞杆 H 在气缸 A 头部合适的填料函中工作。

This rod is prolonged on one side and extends through bearings V in a cylinder I suitably mounted or supported in line with the first, and within which is a disk or plunger J carried by the rod H.

杆 H 在一侧延长，并延伸穿过气缸 I 中的轴承 V，气缸 I 与该杆成一条直线地被适当安装或支撑，在气缸 I 内是由杆 H 携带的一个圆盘或柱塞 J。

The cylinder I is without ports of any kind and is air-tight, except as a small leakage may occur through the bearings V, which experience has shown need not be fitted with any very considerable accuracy.

气缸 I 没有任何类型的气口，并且是气密的，除了通过轴承 V 可能发生小的泄漏，经验表明不需要非常精确地装配。

The cylinder I is surrounded by a jacket K which leaves an open space or chamber around it. The bearings V in the cylinder I, extend through the jacket K to the outside air and the chamber between the cylinder and jacket is made steam or air tight as by suitable packing.

气缸 I 被一个夹套 K 包围，夹套 K 在其周围留下一个开放的空间或腔室。气缸 I 中的轴承 V 穿过夹套 K 延伸到外部空气中，并且气缸和夹套之间的腔室通过适当的填料被制成蒸汽密封或空气密封的。

The main supply pipe L for steam or compressed air leads into this chamber, and the two pipes that lead to the cylinder A run from the said chamber, oil cups M being conveniently arranged to deliver oil into the said pipes for lubricating the piston.

蒸汽或压缩空气的主供应管 L 通向该腔室，通向气缸 A 的两个管从所述腔室延伸，油杯 M 被方便地设置成将油输送到所述管中以润滑活塞。

In the particular form of engine shown, the jacket K which contains the cylinder I is provided with a flange N by which it is screwed to the end of the cylinder A. A small chamber O is thus formed which has air vents P in its sides and drip pipes Q leading out from it through which the oil which collects in it is carried off.

在所示的特定形式的发动机中，容纳气缸 I 的夹套 K 设有凸缘 N，通过该凸缘 N，夹套 K 被拧到气缸 A 的端部。因此形成了一个小腔室 O，该小腔室 O 在其侧面具有通气孔 P 和从该小腔室引出的滴油管 Q，通过该滴油管，小腔室中的油被收集并被带走。

To explain now the operation of the engine described:

现在解释所述发动机的运行:

In the position of the parts shown, or when the piston is at the middle point of its stroke, the plunger

J is at the center of the cylinder I and the air on both sides of the same is at the normal pressure of the outside atmosphere. If a source of steam or compressed air be then connected to the inlet ports C C of the cylinder A and a movement be imparted to the piston as by a sudden blow, the latter is caused to reciprocate in a manner well understood.

在所示部件的位置，或者当活塞处于其冲程的中点时，柱塞J处于气缸I的中心，并且其两侧的空气处于外部大气的正常压力下。如果蒸汽源或压缩空气源连接到气缸A的进气口C C，并通过突然的吹气使活塞运动，活塞就会以一种众所周知的方式往复运动。

The movements of the piston compress and rarefy the air in the cylinder I at opposite ends of the same alternately. A forward stroke compresses the air ahead of the plunger J which acts as a spring to return it, similarly on the back stroke the air is compressed on the opposite side of the plunger J and tends to drive it forward.

活塞的运动在气缸I的相对两端交替地压缩和稀薄化气缸I中的空气。向前的一个冲程压缩柱塞J前面的空气，柱塞J作为一个弹簧使空气回弹，类似地，在向后的冲程中，空气在柱塞J的对侧被压缩，并趋向于向前驱动活塞J。

The compressions of the air in the cylinder I and the consequent loss of energy due mainly to the imperfect elasticity of the air, give rise to a very considerable amount of heat. This heat I utilize by conducting the steam or compressed air to the engine cylinder through the chamber formed by the jacket surrounding the air-spring cylinder. The heat thus taken up and used to raise the temperature of the steam or air acting upon the piston is availed of to increase the efficiency of the engine.

气缸I中的空气压缩和所引发的主要由于空气的不完全弹性造成的能量损失，产生了相当大的热量。我将蒸汽或压缩空气通过空气弹簧气缸周围的夹套形成的腔室来导入发动机气缸，我利用这种热量。这样被吸收的热量用来提高作用在活塞上的蒸汽或空气的温度，从而提高了发动机的效率。

In any given engine of this kind the normal pressure will produce a stroke of determined length, and this will be increased or diminished according to the increase of pressure above or the reduction of pressure below the normal.

在任何给定的这种发动机中，正常压力将产生一个确定长度的冲程，这将根据高于正常压力的压力增加或低于正常压力的压力减少而增加或减少。

In constructing the apparatus proper allowance is made for a variation in the length of stroke by giving to the confining cylinder I of the air spring properly determined dimensions. The greater the pressure upon the piston, the higher will be the degree of compression of the air-spring, and the consequent counteracting force upon the plunger.

在构建该装置时，通过为空气弹簧的限制气缸I确定适当的尺寸，为冲程长度的变化提供了适当的余量。活塞上的压力越大，空气弹簧的压缩程度就越高，因此作用在柱塞上的反作用力就越高。

The rate or period of reciprocation of the piston however, is mainly determined, as above set forth, by the rigidity of the air spring and the inertia of the moving system, and any period of oscillation within very wide limits may be secured by properly proportioning these factors, as by varying the dimensions of the air chamber which is equivalent to varying the rigidity of the spring, or by adjusting the weight of the moving parts.

然而,如上所述,活塞往复运动的速率或周期主要由空气弹簧的刚度和运动系统的惯性决定,并且通过适当地调整这些因素的比例,比如通过改变空气腔的尺寸,这相当于改变弹簧的刚度,或者通过调节运动部件的重量,可以确保在非常宽的范围内的任何振动周期。

These conditions are all readily determinable, and an engine constructed as herein described may be made to follow the principle of operation above stated and maintain a perfectly uniform period through very wide limits of pressure.

这些条件都是容易确定的,并且如本文所述构造的发动机可以遵循上述运行原理,并且通过非常宽的压力极限范围保持完全一致的周期。

The pressure of the air confined in the cylinder when the plunger I is in its central position will always be practically that of the surrounding atmosphere, for while the cylinder is so constructed as not to permit such sudden escape of air as to sensibly impair or modify the action of the air spring there will still be a slow leakage of the air into or out of it around the piston rod according to the pressure therein, so that the pressure of the air on opposite sides of the plunger will always tend to remain at that of the outside atmosphere.

当柱塞 I 处于其中心位置时,限制在气缸中的空气压力实际上将总是周围大气的压力,因为虽然气缸被构造成不允许空气突然逸出而明显削弱或改变空气弹簧的作用,但是根据其中的压力,空气仍然会在活塞杆周围缓慢地泄漏到气缸中或从气缸中泄漏出来,使得柱塞的对侧的空气压力将总是倾向于保持在外部大气的压力。

To the piston rod H is secured a conductor or coil of wire D^1 which by the movements of the piston is oscillated in the magnetic field produced by two magnets $B^1 B^1$ which may be permanent magnets or energized by coils $C^1 C^1$ connected with a source of continued currents E^1 . The movement of the coil D^1 across the lines of force established by the magnets gives rise to alternating currents in the coil. These currents, if the period of mechanical oscillation be constant will be of constant period, and may be utilized for any purpose desired.

导线 D^1 的一个导体或线圈被固定到活塞杆 H 上,该导体或线圈通过活塞的运动在由两个磁体 $B^1 B^1$ 产生的磁场中振荡,磁体 $B^1 B^1$ 可以是永磁体或者由与一个恒向电源 E^1 连接的线圈 $C^1 C^1$ 所励磁。线圈 D^1 穿过由磁体建立的磁力线的运动在线圈中产生交变电流。如果机械振荡的周期是恒定的,这些电流的周期也将是恒定的,并且可以用于任何需要的目的。

In the case under consideration it is assumed as a necessary condition that the inertia of the movable element of the generator and the electro-magnetic reaction which it exerts will not be of such character as to materially disturb the action of the engine.

在所考虑的情况下，假定一个必要条件，即发电机的可移动组件的惯性和它所施加的电磁反作用不会严重干扰发动机的动作。

Fig. 2 is an example of a combination in which the engine is not of itself capable of determining entirely the period of oscillation, but in which the generator contributes to this end. In this figure the engine is the same as in Fig. 1. The exterior air spring is however omitted and the air space at the ends of the cylinder A relied on for accomplishing the same purpose. As the pressure in these spaces is liable to variations from variations in the steam or gas used in impelling the piston they might affect the period of oscillation, and the conditions are not as stable and certain as in the case of an engine constructed as in Fig. 1. But if the natural period of vibration of the electric system be made to approximately accord with the average period of the engine, such tendencies to variation are very largely overcome and the engine will preserve its period even through a considerable range of variations of pressure.

图 2 是一个组合的例子，其中发动机本身不能完全确定振荡周期，但是发电机有助于实现这一目标。在该图中，发动机与图 1 中的发动机相同。然而，省略了外部空气弹簧，并且依赖气缸 A 端部的空气空间来实现相同的目的。由于这些空间中的压力容易随着用于推动活塞的蒸汽或气体的变化而变化，它们可能会影响振荡周期，并且情况不像图 1 中构造的发动机的情况那样稳定和确定。但是，如果电气系统振动的固有周期大致符合发动机的平均周期，这种变化的趋势在很大程度上被克服，即使发动机经历相当大范围的压力变化，它也将保持自己的周期。

The generator in this case is composed of a magnetic casing F^1 in which a laminated core G^1 secured to the piston rod H is caused to vibrate. Surrounding the plunger are two exciting coils $C^1 C^1$, and one or more induced coils $D^1 D^1$.

在这种情况下，发电机由一个磁性壳体 F^1 组成，在该壳体中，固定到活塞杆 H 上的叠片铁芯 G^1 产生振动。围绕柱塞的是两个励磁线圈 $C^1 C^1$ 和一个或多个感应线圈 $D^1 D^1$ 。

The coils $C^1 C^1$ are connected with a generator of continuous currents E^1 and are wound to produce consequent poles in the core G^1 . Any movement of the latter will therefore shift the lines of force through coils $D^1 D^1$ and produce currents therein.

线圈 $C^1 C^1$ 被连接到一个恒向电流发电机 E^1 ，并且线圈 $C^1 C^1$ 被绕制用来产生铁芯 G^1 中的磁极。因此，铁芯 G^1 的任何运动都会移动磁力线通过线圈 $D^1 D^1$ ，并在其中产生电流。

In the circuit of coils D^1 is shown a condenser H^1 . It need only be said that by the use of a proper condenser the self-induction of this circuit may be neutralized. Such a circuit will have a certain natural period of vibration, that is to say that when the electricity therein is disturbed in any way an electrical vibration of a certain period takes place, and as this depends upon the capacity and self-induction, such period may be varied to approximately accord with the period of the engine.

在线圈 D^1 的电路中，展示了一个电容器 H^1 。只需要说，通过使用适当的电容器，这个电路的自感可以被抵消。这种电路将具有一定的固有振动周期，也就是说，当其中的电以任何方式受到扰动时，会发生一定周期的电振动，并且由于这取决于电容量和自感，这种周期可以变化以与发动机的周期近似一致。

In case the power of the engine be comparatively small as when the pressure is applied through a very small fraction of the total stroke, the electrical vibration will tend to control the period, and it is clear that if the character of such vibration be not very widely different from the average period of vibration of the engine under ordinary working conditions that such control may be entirely adequate to produce the desired results.

在发动机的功率相对较小的情况下，当由总冲程的非常小的一部分来施加压力时，电振动将倾向于控制周期，并且很明显，如果这种振动的特征与发动机在普通工作条件下的平均振动周期不是非常大的不同，那么这种控制可能完全足以产生预期的结果。

It is evident that when a conductor in a magnetic field or a magnetic core, is vibrated by mechanism such as is here described the character of the current impulses developed will vary according to existing conditions, as for example, the current impulses may lag behind the electro-motive impulses more or less, and from this it may result that the positive and negative impulses in certain cases may differ in electro-motive force, or the degree of saturation of the core may modify the character of the currents. Thus it is possible in such apparatus, as I have described, to secure a preponderance of the electro-motive impulses of one direction over those in the other, and by a proper observance of these conditions I am able to produce effects similar to those produced by unidirectional currents.

很明显，当磁场中的一个导体或一个磁芯由这里描述的机制所振动时，产生的电流脉冲的特性将根据现有条件而变化，例如，电流脉冲可能或多或少地滞后于电动势脉冲，由此可能导致在某些情况下正脉冲和负脉冲的电动势可能不同，或者铁芯的饱和度可能改变电流的特性。因此，正如我所描述的，在这样的设备中确保一个方向的电脉冲比另一个方向的电脉冲有优势是有可能的，通过适当观察这些条件，我能够产生类似于单向电流产生的效果。

Having now particularly described and ascertained the nature of my said invention, and in what manner the same is to be performed, I declare that what I claim is:

现在已经特别描述和确定了我所述发明的实质，以及以何种方式实施该发明，我声明我主张的是：

1.The combination with the piston or equivalent element of an engine which is free to reciprocate under the action thereon of steam or a gas under pressure, of the moving conductor or element of an electric generator in direct mechanical connection therewith.

1、一个发动机的活塞或等效组件与一个发电机的移动导体或组件的组合，活塞或等效组件在处于压力下的蒸汽或气体的作用下可自由往复运动，发电机与活塞或等效组件直接机械连接。

2. The combination with the piston or equivalent element of an engine which is free to reciprocate under the action of steam or a gas under pressure, of the moving conductor or element of an electric generator in direct mechanical connection therewith, the engine and generator being adapted by their relative adjustment with respect to period to produce currents of constant period, as set forth.

2、存在一个组合，它包括：发动机的活塞或等效组件，能在蒸汽或压力气体的作用下可自

由往复运动；一个发电机的移动导体或组件，与该发电机直接机械连接；通过关于周期的相对调整而适于产生恒定周期的电流的发动机和发电机，如上所述。

3.The combination with an engine comprising a piston free to reciprocate under the action of steam or a gas under pressure, and an electric generator composed of field magnets or coils and a core or conductor capable of oscillation in the field produced thereby, the said core or conductor being carried by the piston rod of the engine as set forth.

3、存在一个组合，它包括：一种发动机，它由处于压力下的蒸汽或气体作用而产生自由往复运动的活塞组成；一种发电机，它由场磁体或场线圈和能够在前者产生的磁场中振荡的一个磁芯或者导体构成，所述磁芯或者导体由发动机的活塞棒所携带，如前所述。

4.The combination with an engine operated by steam or a gas under pressure and having a constant period of reciprocation, of an electric generator, the moving conductor or element of which is connected with the engine, the generator and its circuit being so related to the engine as not to disturb its period as set forth.

4、存在一个组合，它包括：一种由压力下的蒸汽或气体所驱动的并具有一个恒定周期的发动机；一个发电机，其自身的可移动导体或组件与活塞连接，发电机及其电路与发动机的关系不会干扰发动机的周期，如前所述。

5.The combination with a cylinder and a piston reciprocated by steam or a gas under pressure of a spring maintained in vibration by the movement of the piston, and an electric generator, the movable conductor or element of which is connected with the piston, these elements being constructed and adapted in the manner set forth for producing a current of constant period.

5、存在一个组合，它包括：一个气缸和一个活塞，该气缸和活塞由处于一个弹簧的压力下的蒸汽或气体驱动来进行往复运动，该弹簧通过活塞的运动保持振动；一个发电机，其自身的可移动导体或组件与活塞连接；这些组件以所述的方式构建和调整，以产生恒定周期的电流。

6.The method of producing electric currents of constant period herein described which consists in imparting the oscillations of an engine to the moving element of an electric generator and regulating the period of mechanical oscillation by an adjustment of the reaction of the electric generator, as herein set forth.

6、存在一个组合，它包括：本文所述的产生恒定周期电流的方法，它在于将一个发动机的振荡传递给一个发电机的运动组件以及通过对发电机的反作用的一个调节来调整机械振荡的周期，如上所述。

Dated the 16th day of January 1894.

日期 1894 年 1 月 16 日。

Nikola Tesla.
尼古拉·特斯拉

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FIG. 1

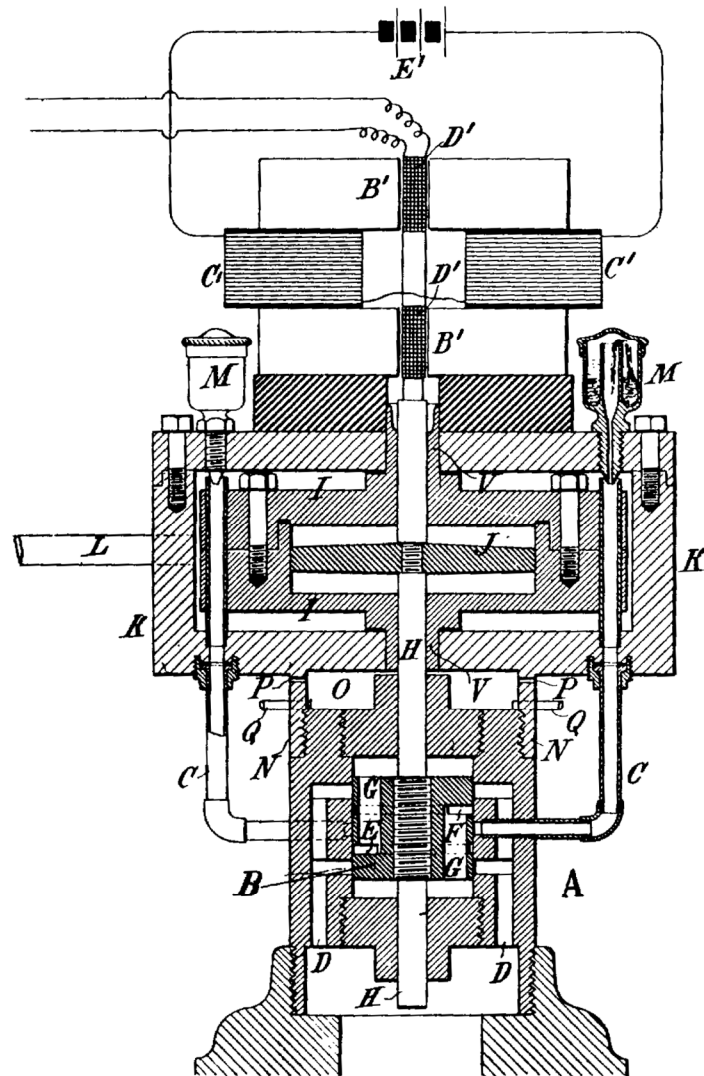
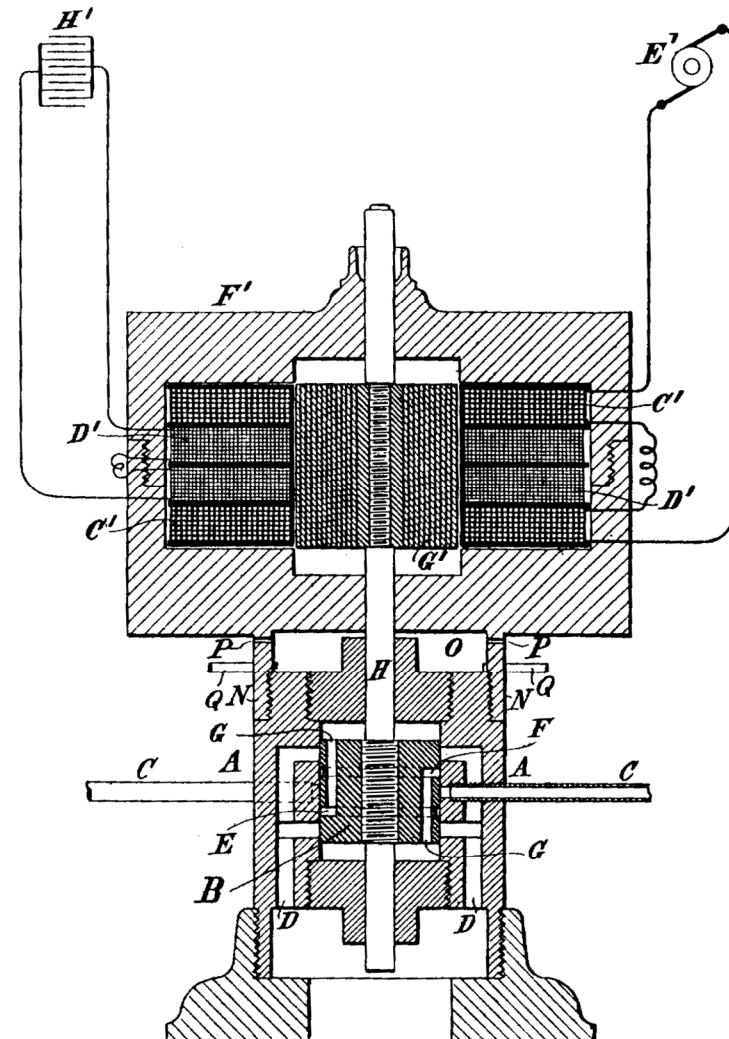


FIG. 2



ELECTRIC GENERATOR.

发电机

NIKOLA TESLA, OF NEW YORK, N. Y.

纽约州纽约市的尼古拉·特斯拉

SPECIFICATION forming part of Letters Patent No. 511,916, dated January 2, 1894.

Application filed August 19, 1893. Serial No. 483,562. (No model.)

该说明书形成了颁发于 1894 年 1 月 2 日编号为 511,916 的专利证书的一部分。

申请于 1893 年 1 月 2 日提交。序列号为 511,916。(没有模型)

To all whom it may concern:

致所有相关人员:

Be it known that I, NIKOLA TESLA, a citizen of the United States, residing at New York, in the county and State of New York, have invented certain new and useful Improvements in Electric Generators, of which the following is a specification, reference being had to the drawings accompanying and forming a part of the same.

众所周知，我，尼古拉·特斯拉，一名美国公民，居住在纽约州纽约郡纽约市，在发电机方面已经发明了某些新的和有用的改进，以下是该发明一个说明书，必须参考随附的图纸，它已形成了该说明书的一部分。

In an application of even date herewith, Serial No. 483,563, I have shown and described a form of engine invented by me, which, under the influence of an applied force such as the elastic tension of steam or a gas under pressure, yields an oscillation of constant period.

与本申请同日提交的序列号为 483,563 的申请中，我已经展示并描述了我发明的一种形式的发动机，它在作用力（如处于压力下的蒸汽或一种气体的弹性张力）的影响下，会产生一个恒定周期的振荡。

In order that my present invention may be more readily understood I will explain the conditions which are to be observed in order to secure this result.

为了更容易理解我的发明，我将解释为了保证这一结果所要观察的条件。

It is a well known mechanical principle that if a spring possessing a sensible inertia be brought under tension, as by being stretched, and then freed, it will perform vibrations which are isochronous, and as to period, in the main, dependent upon the rigidity of the spring, and its own inertia or that of the system of which it may form an immediate part. This is known to be true in all cases where the force which tends to bring the spring or movable system into a given position is proportionate to the

displacement.

一个众所周知的机械原理是，如果一个弹簧拥有一个敏感的惯性，在拉力下被拉伸，然后释放，那么它将执行等时振动，至于周期，主要取决于弹簧的刚度，以及它自己的惯性或系统的可以构成一个直接部分的惯性。众所周知，在倾向于将弹簧或可移动的系统带到给定位置的力与位移成正比的所有情况下，这都是正确的。

In the construction of my engine above referred to I have followed and applied this principle, that is to say, I employ a cylinder and a piston which in any suitable manner I maintain in reciprocation by steam or gas under pressure. To the moving piston or to the cylinder, in case the latter reciprocate and the piston remain stationary, a spring is connected so as to be maintained in vibration thereby, and whatever may be the inertia of the piston or the moving system and the rigidity of the spring relatively to each other, provided, the practical limits within which the law holds true that the forces which tend to bring the moving system to a given position are proportionate to the displacement, are not exceeded, the impulses of the power impelled piston and the natural vibrations of the spring will always correspond in direction and coincide in time. In the case of the engine referred to, the ports are so arranged that the movement of the piston within the cylinder in either direction ceases when the force tending to impel it and the momentum which it has acquired are counterbalanced by the increasing pressure of the steam or compressed air in that end of the cylinder toward which it is moving, and as in its movement the piston has shut off at a given point, the pressure that impelled it and established the pressure that tends to return it, it is then impelled in the opposite direction, and this action is continued as long as the requisite pressure is applied. The length of the stroke will vary with the pressure, but the rate or period of reciprocation is no more dependent upon the pressure applied to drive the piston, than would be the period of oscillation of the pendulum permanently maintained in vibration, upon the force which periodically impels it, the effect of variations in such force being merely to produce corresponding variations in the length of stroke or amplitude of vibration respectively.

在上面提到的我的发动机的结构中，我遵循并应用了这个原理，也就是说，我使用了一个气缸和一个活塞，我以任何合适的方式利用处于压力下的蒸汽或气体来维持往复运动。在活塞往复运动和气缸保持静止的情况下，连接了一个弹簧，从而由该弹簧保持振动，无论活塞或运动系统的惯性以及弹簧相对于彼此的刚度如何，只要不超过实际极限，在该限度内，规律成立，趋向于将运动系统带到给定位置的力与位移成正比，动力推动活塞的脉冲和弹簧的自然振动将总是在方向上一致，在时间上重合。在所提及的发动机的情况下，部件被如此布置，使得当倾向于推动活塞的力和活塞已获得的动量被活塞正在移动朝向的气缸端部中的蒸汽或压缩空气的正在增加的压力所抵消时，活塞在气缸内的任一方向上的运动将停止，并且当活塞在运动中停止在给定点时，推动它的压力建立了倾向于退回它的压力，然后它被推向相反的方向，只要必要的压力被施加，这个动作就将继续。冲程的长度将随压力而变化，但是往复运动的速率或周期不再取决于驱动活塞所施加的压力，而是取决于永久保持振动的摆锤的振荡周期，取决于周期性推动它的力，这种力的变化的影响仅仅是分别产生冲程长度或振动幅度的相应变化。

In practice I have found that the best results are secured by the employment of an air spring, that is, a body of confined air or gas which is compressed and rarefied by the movements of the piston, and in order to secure a spring of constant rigidity I prefer to employ a separate chamber or cylinder containing air at the normal atmospheric pressure, although it might be at any other pressure, and in which works

a plunger connected with or carried by the piston rod. The main reason why no engine heretofore has been capable of producing results of this nature is that it has been customary to connect with the reciprocating parts a heavy fly-wheel or some equivalent rotary system of relatively very great inertia, or in other cases where no rotary system was employed, as in certain reciprocating engines or tools, no regard has been paid to the obtainment of the conditions essential to the end which I have in view, nor would the pressure of such conditions in said devices appear to result in any special advantage.

在实践中,我发现最好的结果是通过使用空气弹簧来确保的,即利用活塞的运动来压缩和稀薄化被封闭的空气或气体,以确保弹簧的恒定刚性,我更喜欢使用一个单独的腔室或气缸,其中包含正常大气压下的空气,尽管它可以处于任何其他压力下,并且在其中工作的柱塞与活塞杆连接或由活塞杆携带。迄今为止,没有发动机能够产生这种性质的结果的主要原因是,习惯上将重型飞轮或一些惯性相对较大的等效旋转系统与往复运动部件连接,或者在没有使用旋转系统的其他情况下,如在某些往复运动发动机或工具中,没有考虑获得我所考虑的目的所必需的条件,在所述设备中存在这些条件似乎也不会产生任何特殊优势。

Such an engine as I have described affords a means for accomplishing a result heretofore unattained, the continued production of electric currents of constant period, by imparting the movements of the piston to a core or coil in a magnetic field. It should be stated however, that in applying the engine for this purpose certain conditions are encountered which should be taken into consideration in order to satisfactorily secure the desired result. When a conductor is moved in a magnetic field and a current caused to circulate therein, the electro-magnetic reaction between it and the field, might disturb the mechanical oscillation to such an extent as to throw it out of isochronism. This, for instance, might occur when the electro-magnetic reaction is very great in comparison to the power of the engine, and there is a retardation of the current so that the electro-magnetic reaction might have an effect similar to that which would result from a variation of the tension of the spring, but if the circuit of the generator be so adjusted that the phases of the electromotive force and current coincide in time, that is to say, when the current is not retarded, then the generator driven by the engine acts merely as a frictional resistance and will not, as a rule, alter the period of the mechanical vibration, although it may vary its amplitude. This condition may be readily secured by properly proportioning the self induction and capacity of the circuit including the generator. I have, however, observed the further fact in connection with the use of such engines as a means for running a generator, that it is advantageous that the period of the engine and the natural period of electrical vibration of the generator should be the same, as in such case the best conditions for electrical resonance are established and the possibility of disturbing the period of mechanical vibrations is reduced to a minimum. I have found that even if the theoretical conditions necessary for maintaining a constant period in the engine itself are not exactly maintained, still the engine and generator combined will vibrate at a constant period. For example, if instead of using in the engine an independent cylinder and plunger, as an air spring of practically constant rigidity, I cause the piston to impinge upon air cushions at the ends of its own cylinder, although the rigidity of such cushions or springs might be considerably affected and varied by the variations of pressure within the cylinder, still by combining with such an engine a generator which has a period of its own approximately that of the engine, constant vibration may be maintained even through a considerable range of varying pressure, owing to the controlling action of the electro-magnetic system. I have even found that under certain conditions the influence of the electro-magnetic system may be made so great as to entirely control the period of the mechanical vibration within wide limits of varying pressure. This is likely to occur in those instances where the power of the engine while fully capable of maintaining a

vibration once started, is not sufficient to change its rate. So, for the sake of illustration, if a pendulum is started in vibration, and a small force applied periodically in the proper direction to maintain it in motion, this force would have no substantial control over the period of the oscillation, unless the inertia of the pendulum be small in comparison to the impelling force, and this would be true no matter through what fraction of the period the force may be applied. In the case under consideration the engine is merely an agent for maintaining the vibration once started, although it will be understood that this does not preclude the performance of useful work which would simply result in a shortening of the stroke. My invention, therefore, involves the combination of a piston free to reciprocate under the influence of steam or a gas under pressure and the movable element of an electric generator which is in direct mechanical connection with the piston, and it is more especially the object of my invention to secure from such combination electric currents of a constant period. In the attainment of this object I have found it preferable to construct the engine so that it of itself controls the period, but as I have stated before, I may so modify the elements of the combination that the electro-magnetic system may exert a partial or even complete control of the period.

我所描述的这种发动机提供了一种手段来实现迄今为止未实现的一种结果, 通过将活塞的运动传递给磁场中的一个铁芯或一个线圈, 持续产生恒定周期的电流。然而, 应该指出的是, 在为此目的应用发动机时, 会遇到某些情况, 为了令人满意地确保期望的结果, 应该考虑这些情况。当一个导体在磁场中运动并且电流在该导体中循环时, 导体和磁场之间的电磁反作用可能会干扰机械振荡, 使其脱离等时振荡。例如, 当电磁反作用与发动机的功率相比非常大时, 这可能发生, 并且存在电流的延迟, 使得电磁反作用可能具有类似于由弹簧拉力的变化所产生的效果, 但是, 如果发电机的电路被如此调节, 使得电动势和电流的相位在时间上一致, 也就是说, 当电流不被阻滞时, 由发动机驱动的发电机仅起摩擦阻力的作用, 尽管它可以改变机械振动的振幅, 但通常不会改变机械振动的周期。通过适当地调整包括发电机在内的电路的自感应和电容量, 可以很容易地确保这种情况。然而, 我已经观察到与将这样的发动机作为一个工具来运行一个发电机的用法有关的进一步事实, 即发动机的周期和发电机的电振动的自然周期应该相同是有利的, 因为在这种情况下, 建立了电共振的最佳条件, 并且干扰机械振动周期的可能性降低到最小。我已经发现即使发动机本身保持一个恒定周期所必需的理论条件不能精确地保持, 发动机和发电机组合在一起仍然会以恒定的周期振动。例如, 如果不在发动机中使用独立的气缸和柱塞作为实际上具有恒定刚度的空气弹簧, 而是用活塞撞击其气缸端部的气垫, 尽管这种气垫或弹簧的刚度可能会受到气缸内的压力变化显著地影响和改变, 但仍然通过将这种发动机与一个发电机相结合(该发电机有与该发动机的周期相近的一个周期), 由于电磁系统的控制作用, 即使在相当大的压力变化范围内, 也可以保持恒定的振动。我甚至发现, 在某些条件下, 电磁系统的影响可能如此之大, 以至于在变化压力的宽限度范围内完全控制机械振动的周期。这很可能发生在发动机功率虽然完全能够在一启动后保持振动, 但不足以改变其速度的情况下。因此, 为了说明, 如果一个摆锤开始振动, 一个小的力被周期性地施加在正确的方向上以保持它的运动, 这个力将不会对振荡的周期有实质性的控制, 除非钟摆的惯性与推动力相比是小的, 不管在这个周期的哪一小段施加这个力, 事实都将是这样。在所考虑的情况下, 发动机仅仅是用于在一启动后保持振动的作用因素, 尽管应该理解这并不妨碍将简单地导致冲程缩短的有用功的执行。因此, 我的发明包括在处于压力下的蒸汽的或气体的影响下, 自由往复运动的活塞和与活塞直接机械连接的发电机的可移动组件的组合, 并且更具体地说, 我的发明的目的是从这种组合中获得一个恒定周期的电流。为了达到这个目的, 我发现最好是这样构建发动机, 使它自己控制周期, 但正如我以前说过的, 我可以修改该组合的组件, 电磁系统可以部分地甚至完全控制周期。

In illustration of the manner in which the invention is carried out I now refer to the accompanying drawings.

为了说明实施本发明的方式，我现在参考附图：

Figure 1 is a central sectional view of an engine and generator embodying the invention. Fig. 2 is a modification of the same.

图 1 是体现本发明的发动机和发电机的中心截面图。图 2 是对该截面图的一个修改。

Referring to Fig. 1 A is the main cylinder in which works a piston B. Inlet ports C C pass through the sides of the cylinder opening at the middle portion thereof and on opposite sides. Exhaust ports D D extend through the walls of the cylinder and are formed with branches that open into the interior of the cylinder on each side of the inlet ports and on opposite sides of the cylinder. The piston B is formed with two circumferential grooves E F which communicate through openings G in the piston with the cylinder on opposite sides of said piston respectively.

参照图 1，A 是主气缸，活塞 B 在其中工作。进气口 C C 穿过气缸中部的并且位于气缸对侧的开孔。排气口 D D 延伸穿过气缸壁，并在进气口的每一侧和气缸的对侧形成有通向气缸内部的支路。活塞 B 形成有两个环状凹槽 E F，它们通过活塞中的开口 G 分别与所述活塞对侧的气缸连通。

The particular construction of the cylinder, the piston and the ports controlling it may be very much varied, and is not in itself material, except that in the special case now under consideration it is desirable that all the ports, and more especially the exhaust ports should be made very much larger than is usually the case so that no force due to the action of the steam or compressed air will tend to retard or affect the return of the piston in either direction. The piston B is secured to a piston rod H which works in suitable stuffing boxes in the heads of the cylinder A. This rod is prolonged on one side and extends through bearings V in a cylinder I suitably mounted or supported in line with the first, and within which is a disk or plunger J carried by the rod H. The cylinder I is without ports of any kind and is air-tight except as a small leakage may occur through the bearings V, which experience has shown need not be fitted with any very considerable accuracy. The cylinder I is surrounded by a jacket K which leaves an open space or chamber around it. The bearings V in the cylinder I, extend through the jacket K to the outside air and the chamber between the cylinder and jacket is made steam or air-tight as by a suitable packing. The main supply pipe L for steam or compressed air leads into this chamber, and the two pipes that lead to the cylinder A run from the said chamber, oil cups M being conveniently arranged to deliver oil into the said pipes for lubricating the piston. In the particular form of engine shown, the jacket K which contains the cylinder I is provide with a flange N by which it is screwed to the end of the cylinder A. A small chamber O is thus formed which has air vents P in its sides and drip pipes Q leading out from it through which the oil which collects in it is carried off.

气缸的、活塞的和用于控制活塞的气口的具体结构可以有很大的变化，其材料本身并不重要，除了在现在考虑的特殊情况下，希望所有的气口，尤其是排气口应该比通常的情况大得多，这样就不会由于蒸汽或压缩空气的作用而产生倾向于阻碍或影响活塞在任一方向上返回的力。活塞 B 被固定在一个活塞杆 H 上，活塞杆 H 在气缸 A 头部合适的填料函中工作。杆 H

在一侧延长,并延伸穿过气缸 I 中的轴承 V,气缸 I 与该杆成一条直线地被适当安装或支撑,在气缸 I 内是由杆 H 携带的一个圆盘或柱塞 J。气缸 I 没有任何类型的气口,并且是气密的,除了通过轴承 V 可能发生小的泄漏,经验表明不需要非常精确地装配。气缸 I 被一个夹套 K 包围,夹套 K 在其周围留下一个开放的空间或腔室。气缸 I 中的轴承 V 穿过夹套 K 延伸到外部空气中,并且气缸和夹套之间的腔室通过适当的填料被制成蒸汽密封或空气密封的。蒸汽或压缩空气的主供应管 L 通向该腔室,通向气缸 A 的两个管从所述腔室延伸,油杯 M 被方便地设置成将油输送到所述管中以润滑活塞。在所示的特定形式的发动机中,包含气缸 I 的夹套 K 设有凸缘 N,通过该凸缘 N,夹套 K 被拧到气缸 A 的端部。因此形成了一个小腔室 O,该小腔室 O 在其侧面具有通气孔 P 和从该小腔室引出的滴油管 Q,通过该滴油管,小腔室中的油被收集并被带走。

To explain now the operation of the engine described, in the position of the parts shown, or when the piston is at the middle point of its stroke, the plunger J is at the center of the cylinder I and the air on both sides of the same is at the normal pressure of the outside atmosphere. If a source of steam or compressed air be then connected to the inlet ports C C of the cylinder A and a movement be imparted to the piston as by a sudden blow, the latter is caused to reciprocate in a manner well understood. The movements of the piston compress and rarefy the air in the cylinder I at opposite ends of the same alternately. A forward stroke compresses the air ahead of the plunger J which acts as a spring to return it. Similarly on the back stroke the air is compressed on the opposite side of the plunger J and tends to drive it forward. The compressions of the air in the cylinder I and the consequent loss of energy due mainly to the imperfect elasticity of the air, give rise to a very considerable amount of heat. This heat I utilize by conducting the steam or compressed air to the engine cylinder through the chamber formed by the jacket surrounding the air-spring cylinder. The heat thus taken up and used to raise the temperature of the steam or air acting upon the piston is availed of to increase the efficiency of the engine. In any given engine of this kind the normal pressure will produce a strike of determined length, and this will be increased or diminished according to the increase of pressure above or the reduction of pressure below the normal.

现在解释所述发动机的运行,在所示部件的位置,或者当活塞处于其冲程的中点时,柱塞 J 处于气缸 I 的中心,并且其两侧的空气处于外部大气的正常压力下。如果蒸汽源或压缩空气源连接到汽缸 A 的进气口 C C,并通过突然的吹气使活塞运动,活塞就会以一种众所周知的方式往复运动。活塞的运动在气缸 I 的相对两端交替地压缩和稀薄化气缸 I 中的空气。向前的一个冲程压缩柱塞 J 前面的空气,柱塞 J 作为一个弹簧使空气回弹,类似地,在向后的冲程中,空气在柱塞 J 的对侧被压缩,并趋向于向前驱动活塞 J。气缸 I 中的空气压缩和所引发的主要由于空气的不完全弹性造成的能量损失,产生了相当大的热量。我将蒸汽或压缩空气通过空气弹簧气缸周围的夹套形成的腔室来导入发动机气缸,我利用这种热量。这样被吸收的热量用来提高作用在活塞上的蒸汽或空气的温度,从而提高了发动机的效率。在任何给定的这种发动机中,正常压力将产生一个确定长度的冲程,这将根据高于正常压力的压力增加或低于正常压力的压力减少而增加或减少。

In constructing the apparatus proper allowance is made for a variation in the length of stroke by giving to the confining cylinder I of the air spring properly determined dimensions. The greater the pressure upon the piston, the higher the degree of compression of the air-spring, and the consequent counteracting force upon the plunger. The rate or period of reciprocation of the piston, however, is mainly determined as described above by the rigidity of the air spring and the inertia of the moving

system, and any period of oscillation within very wide limits may be secured by properly portioning these factors, as by varying the dimensions of the air chamber which is equivalent to varying the rigidity of the spring, or by adjusting the weight of the moving parts. These conditions are all readily determinable, and an engine constructed as herein described may be made to follow the principle of operation above stated and maintain a perfectly uniform period through very wide limits of pressure.

在构建该装置时，通过为空气弹簧的限制气缸 I 确定适当的尺寸，为冲程长度的变化提供了适当的余量。活塞上的压力越大，空气弹簧的压缩程度就越高，因此作用在柱塞上的反作用力就越高。然而，如上所述，活塞往复运动的速率或周期主要由空气弹簧的刚度和运动系统的惯性决定，并且通过适当地调整这些因素的比例，比如通过改变空气腔的尺寸，这相当于改变弹簧的刚度，或者通过调节运动部件的重量，可以确保在非常宽的范围内的任何振动周期。这些条件都是容易确定的，并且如本文所述构造的发动机可以遵循上述运行原理，并且通过非常宽的压力限度范围保持完全一致的周期。

The pressure of the air confined in the cylinder when the plunger I is in its central position will always be practically that of the surrounding atmosphere, for while the cylinder is so constructed as not to permit such sudden escape of air as to sensibly impair or modify the action of the air spring there will still be a slow leakage of air into or out of it around the piston rod according to the pressure therein, so that the pressure of the air on opposite sides of the plunger will always tend to remain at that of the outside atmosphere.

当柱塞 I 处于其中心位置时，限制在气缸中的空气压力实际上将总是周围大气的压力，因为虽然气缸被构造成不允许空气突然逸出而明显削弱或改变空气弹簧的作用，但是根据其中的压力，空气仍然会在活塞杆周围缓慢地泄漏到气缸中或从气缸中泄漏出来，使得柱塞的对侧的空气压力将总是倾向于保持在外部大气的压力。

To the piston rod H is secured a conductor or coil of wire D' which by the movements of the piston is oscillated in the magnetic field produced by two magnets B' B' which may be permanent magnets or energized by coils C' C' connected with a source of continuous currents E'. The movement of the coil D' across the lines of force established by the magnets gives rise to alternating currents in the coil. These currents, if the period of mechanical oscillation be constant will be of constant period, and may be utilized for any purpose desired.

导线 D' 的一个导体或线圈被固定到活塞杆 H 上，该导体或线圈通过活塞的运动在由两个磁体 B' B' 产生的磁场中振荡，磁体 B' B' 可以是永磁体或者由与一个恒向电源 E' 连接的线圈 C' C' 所励磁。线圈 D' 穿过由磁体建立的磁力线的运动在线圈中产生交变电流。如果机械振荡的周期是恒定的，这些电流的周期也将是恒定的，并且可以用于任何需要的目的。

In the case under consideration it is assumed as a necessary condition that the inertia of the moveable element of the generator and the electro-magnetic reaction which it exerts will not be of such character as to materially disturb the action of the engine.

在所考虑的情况下，假定一个必要条件，即发电机的可移动组件的惯性和它所施加的电磁反作用的性质不会严重干扰发动机的动作。

Fig. 2 is an example of a combination in which the engine is not of itself capable of determining entirely the period of oscillation, but in which the generator contributes to this end. In this figure the engine is the same as in Fig. 1. The exterior air spring is however omitted and the air spaces at the ends of the cylinder A relied on for accomplishing the same purpose. As the pressure in these spaces is liable to variations from variations in the steam or gas used in impelling the piston they might affect the period of oscillation, and the conditions are not as stable and certain as in the case of an engine constructed as in Fig. 1. But if the natural period of vibration of the elastic system be made to approximately accord with the average period of the engine such tendencies to variation are very largely overcome and the engine will preserve its period even through a considerable range of variations of pressure. The generator in this case is composed of a magnetic casing F' in which a laminated core G' secured to the piston rod H is caused to vibrate. Surrounding the plunger are two exciting coils C' C', and one or more induced coils D' D'. The coils C' C' are connected with a generator of continuous currents E' and are wound to produce consequent poles in the core G'. Any movement of the latter will therefore shift the lines of force through coils D' D' and produce currents therein.

图 2 是一个组合的例子，其中发动机本身不能完全确定振荡周期，但是发电机有助于实现这一目标。在该图中，发动机与图 1 中的发动机相同。然而，省略了外部空气弹簧，并且依赖气缸 A 端部的空气空间来实现相同的目的。由于这些空间中的压力容易随着用于推动活塞的蒸汽或气体的变化而变化，它们可能会影响振荡周期，并且情况不像图 1 中构造的发动机的情况那样稳定和确定。但是，如果电气系统振动的固有周期大致符合发动机的平均周期，这种变化的趋势在很大程度上被克服，发动机将保持它的周期，即使经过相当大范围的压力变化。在这种情况下，发电机由一个磁性壳体 F' 组成，在该壳体中，固定到活塞杆 H 上的叠片铁芯 G' 产生振动。围绕柱塞的是两个励磁线圈 C' C' 和一个或多个感应线圈 D' D'。线圈 C' C' 被连接到一个恒向电流发电机 E'，并且线圈 C' C' 被绕制用来产生铁芯 G' 中的磁极。因此，铁芯 G' 的任何运动都会移动磁力线通过线圈 D' D'，并在其中产生电流。

In the circuit of coils D' is shown a condenser H'. It need only be said that by the use of a proper condenser the self induction of this circuit may be neutralized. Such a circuit will have a certain natural period of vibration, that is to say that when the electricity therein is disturbed in any way an electrical or electro-magnetic vibration of a certain period takes place, and as this depends upon the capacity and self induction, such period may be varied to approximately accord with the period of the engine.

在线圈 D' 的电路中，展示了一个电容器 H'。只需要说，通过使用适当的电容器，这个电路的自感可以被抵消。这种电路将具有一定的固有振动周期，也就是说，当其中的电以任何方式受到扰动时，会发生一定周期的电振动，并且由于这取决于电容量和自感，这种周期可以变化以与发动机的周期近似一致。

In case the power of the engine be comparatively small, as when the pressure is applied through a very small fraction of the total stroke, the electrical vibration will tend to control the period, and it is clear that if the character of such vibration be not very widely different from the average period of vibration of the engine under ordinary working conditions such control may be entirely adequate to produce the desired results.

在发动机的功率相对较小的情况下，当由总冲程的非常小的一部分来施加压力时，电振动将倾向于控制周期，并且很明显，如果这种振动的特征与发动机在普通工作条件下的平均振动

周期不是非常大的不同，那么这种控制可以完全足以产生预期的结果。

Having now described my invention, what I claim is—

现在描述了我的发明，我主张的是—

1. The combination with the piston or equivalent element of an engine which is free to reciprocate under the action thereon of steam or a gas under pressure, of the moving conductor or element of an electric generator in direct mechanical connection therewith.

1、一个发动机的活塞或等效组件与一个发电机的移动导体或组件的组合，活塞或等效组件在压力下的蒸汽或气体的作用下可自由往复运动，发电机与活塞或等效组件直接机械连接。

2. The combination with the piston or equivalent element of an engine which is free to reciprocate under the action of steam or a gas under pressure, of the moving conductor or element of an electric generator in direct mechanical connection therewith, the engine and generator being adapted by their relative adjustment with respect to period to produce currents of constant period, as set forth.

2、存在一个组合，它包括：发动机的活塞或等效组件，能在压力下的蒸汽或气体的作用下可自由往复运动；一个发电机的移动导体或组件，与该发电机直接机械连接；通过关于周期的相对调整而适于产生恒定周期的电流的发动机和发电机，如前所述。

3. The combination with an engine comprising a piston which is free to reciprocate under the action of steam or a gas under pressure, and an electric generator having inducing and induced elements one of which is capable of oscillation in the field of force, the said movable element being carried by the piston rod of the engine, as set forth.

3、存在一个组合，它包括：一种发动机，它由在处于压力下的蒸汽或气体的作用下自由往复运动的活塞组成；一种发电机，它具有施感组件和感应组件，感应组件中的一个能够在磁场中振荡，所述可移动组件由发动机的活塞棒所携带，如前所述。

4. The combination with an engine operated by steam or a gas under pressure and having a constant period of reciprocation, of an electric generator, the moving element of which is carried by the reciprocating part of the engine, the generator and its circuit being so related to the engine with respect to the period of electrical vibration as not to disturb the period of the engine, as set forth.

4、存在一个组合，它包括：一种由压力下的蒸汽或气体所驱动的并有一个恒定周期的发动机；一个发电机，其自身的可移动导体或组件与活塞连接，发电机及其电路与发动机的电气振动周期密切相关，因此不会干扰发动机的周期，如前所述。

5. The combination with a cylinder and a piston reciprocated by steam or a gas under pressure of a spring maintained in vibration by the movement of the piston, and an electric generator, the movable conductor or element of which is connected with the piston, these elements being constructed and adapted in the manner set forth for producing a current of constant period.

5、存在一个组合，它包括：一个气缸和一个活塞，该气缸和活塞由处于一个弹簧的压力下的蒸汽或气体作用来产生往复运动，该弹簧通过活塞的运动保持振动；一个发电机，其自身的可移动导体或组件与活塞连接；这些组件以所述的方式构建和调整，以产生恒定周期的电流。

6. The method of producing electric currents of constant period herein described which consists in imparting the oscillations of an engine to the moving element of an electric generator and regulating the period of mechanical oscillation by an adjustment of the reaction of the electric generator, as herein set forth.

6、存在一个组合，它包括：本文所述的产生恒定周期电流的方法，它在于将一个发动机的振荡传递给一个发电机的运动组件以及通过对发电机的反作用的一个调节来调整机械振荡的周期，如上所述。

NIKOLA TESLA.

尼古拉·特斯拉

Witnesses:

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R. F. GAYLORD.

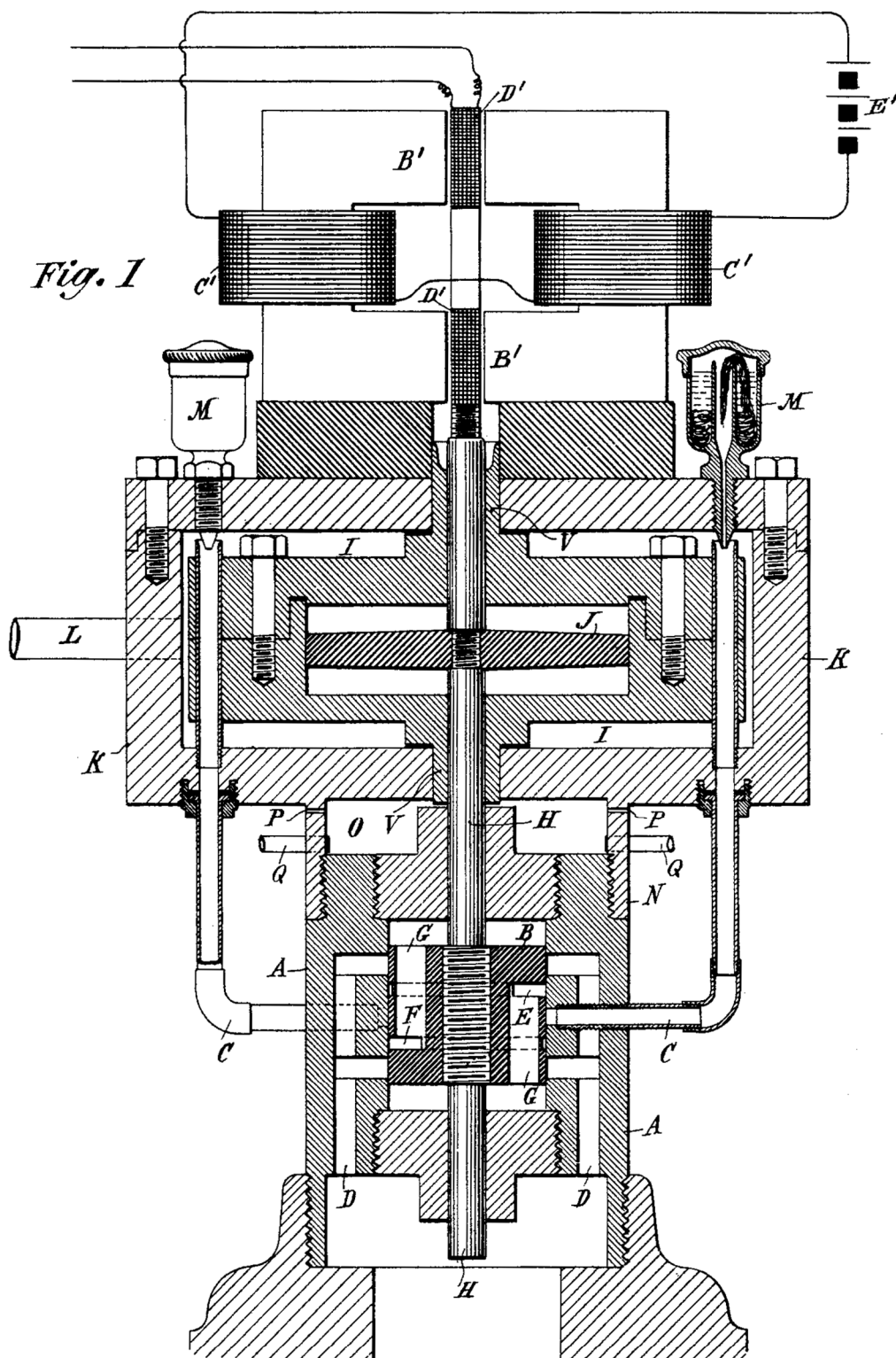
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N. TESLA.
ELECTRIC GENERATOR.

No. 511,916.

Patented Jan. 2, 1894.



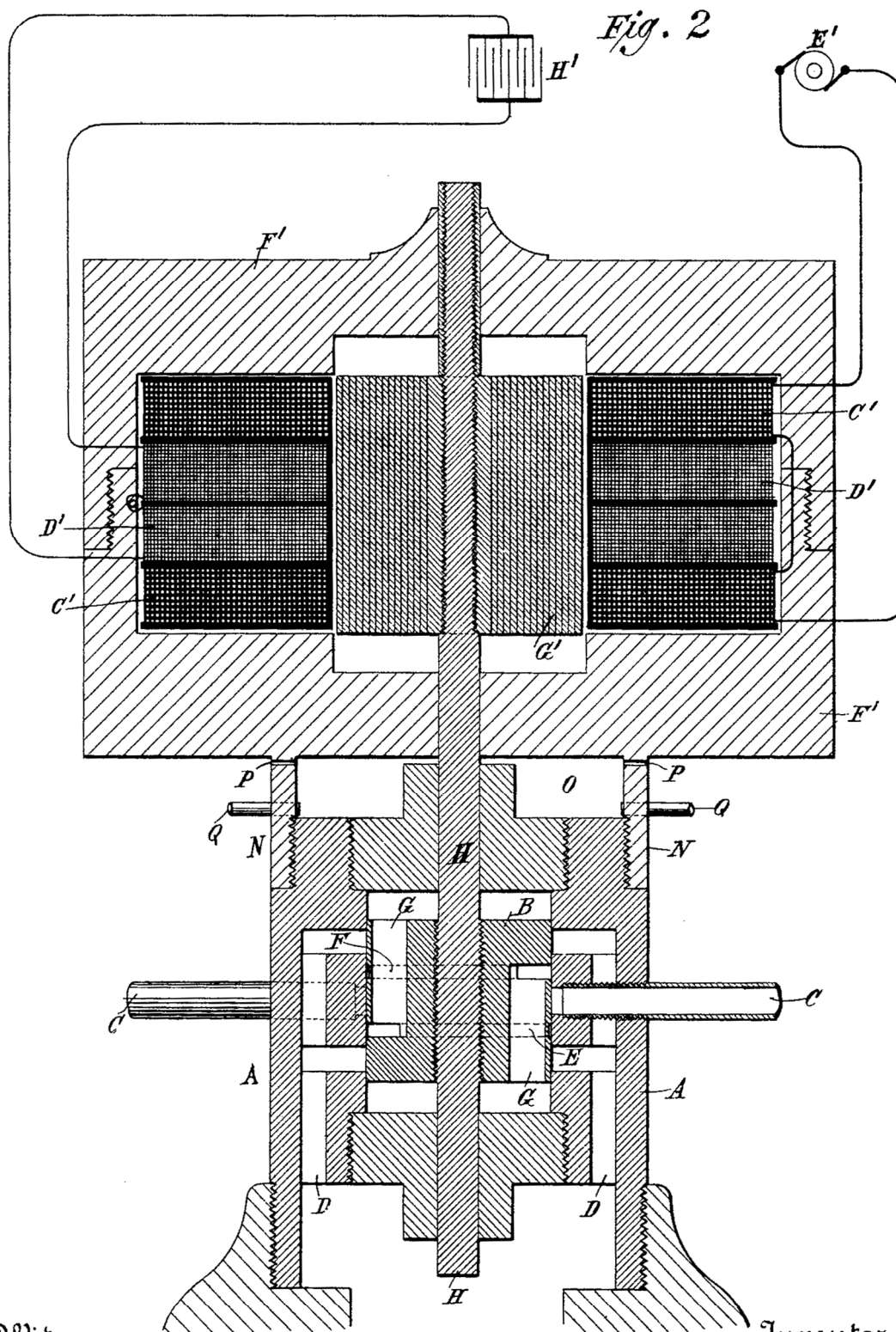
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By his Attorneys
Duncan & Page.

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RECIPROCATING ENGINE.

往复式发动机

NIKOLA TESLA, OF NEW YORK, N. Y.

纽约州纽约市的尼古拉·特斯拉

SPECIFICATION forming part of Letters Patent No. 514,169, dated February 6, 1894.

Application filed August 19, 1893. Serial No. 483,563. (No model.)

该说明书形成了颁发于 1894 年 2 月 6 日编号为 514,169 的专利证书的一部分。

申请于 1893 年 8 月 19 日提交。序列号 483,563。(没有模型)

To all whom it may concern:

致所有相关人士:

Be it known that I, NIKOLA TESLA, a citizen of the United States, residing at New York, in the county and State of New York, have invented certain new and useful Improvements in Reciprocating Engines, of which the following is a specification, reference being had to the drawing accompanying and forming a part of the same.

众所周知，我，尼古拉·特斯拉，一名美国公民，居住在纽约州纽约郡纽约市，在往复式发动机方面已经发明了某些新的和有用的改进，以下是该发明一个说明书，必须参考随附的图纸，它已形成了该说明书的一部分。

In the invention which forms the subject of my present application, my object has been, primarily to provide an engine, which under the influence of an applied force such as the elastic tension of steam or gas under pressure will yield an oscillatory movement which, within very wide limits, will be of constant period, irrespective of variations of load, frictional losses and other factors which in all ordinary engines produce change in the rate of reciprocation.

在构成本申请主题的本发明中，我的目的主要是提供一种发动机，该发动机在作用力的影响下，例如在处于压力下的蒸汽或气体的弹性张力的影响下，将产生一种振荡运动，该振荡运动在很宽的范围内具有恒定的周期，而不用考虑在所有普通发动机中导致往复运动速率变化的负载、摩擦损失和其它因素的变化。

The further objects of the invention are to provide a mechanism, capable of converting the energy of steam or gas under pressure into mechanical power more economically than the forms of engine heretofore used, chiefly by overcoming the losses which result in these by the combination with rotating parts possessing great inertia of a reciprocating system; which also, is better adapted for use at higher temperatures and pressures, and which is capable of useful and practical application to general industrial purposes, particularly in small units.

本发明的另一个目的是提供一种机械装置,该装置能够比迄今使用的各种形式的发动机更经济地将压力下的蒸汽或气体的能量转换成机械动力,主要是通过与往复运动系统中的具有大惯性的旋转部件相结合来克服这些机器中产生的损失;该装置也更适于在较高的温度和压力下使用,并且它能够用于一般的工业目的,特别是在小型装置中。

The invention is based upon certain well known mechanical principles a statement of which will assist in a better understanding of the nature and purposes of the objects sought and results obtained. Heretofore, where the pressure of steam or any gas has been utilized and applied for the production of mechanical motion it has been customary to connect with the reciprocating or moving parts of the engine a fly-wheel or some rotary system equivalent in its effect and possessing relatively great mechanical inertia, upon which dependence was mainly placed for the maintenance of constant speed. This, while securing in a measure this object, renders impossible the attainment of the result at which I have arrived, and is attended by disadvantages which by my invention are entirely obviated. On the other hand, in certain cases, where reciprocating engines or tools have been used without a rotating system of great inertia, no attempt, so far as I know, has been made to secure conditions which would necessarily yield such results as I have reached.

本发明基于某些众所周知的机械原理,这些原理的陈述将有助于更好地理解所寻求的目标和所获得的结果的性质和意图。迄今为止,在利用蒸汽的或任何气体的压力来产生机械运动的情况下,通常将一个飞轮或一些等效的旋转系统与发动机的往复部件或运动部件相连接,并且具有相对较大的机械惯性,这主要为了保持恒定的速度。这虽然在一定程度上保证了这个目标,但却不可能实现我已经达到的结果,并且还伴随着我的发明已完全消除的缺点。另一方面,在某些情况下,往复式发动机或往复式工具已不再使用一个大惯性的旋转系统,据我所知,没有尝试确保就能一定会产生我所达到的结果的条件。

It is a well known principle that if a spring possessing a sensible inertia be brought under tension, as by being stretched, and then freed it will perform vibrations which are isochronous and, as to period, in the main dependent upon the rigidity of the spring, and its own inertia or that of the system of which it may form an immediate part. This is known to be true in all cases where the force which tends to bring the spring or movable system into a given position is proportionate to the displacement.

一个众所周知的原理是,如果一个具有可感知惯性的弹簧受到拉伸,然后被释放,它将执行等时振动,至于周期,主要取决于弹簧的刚度、它自己的惯性或系统的惯性,该弹簧可以形成系统的一个直接部分。众所周知,倾向于将弹簧或可移动系统带到给定位置的力在与位移成正比的所有情况下,这都是正确的。

In carrying out my invention and for securing the objects in general terms stated above, I employ the energy of steam or gas under pressure, acting through proper mechanism, to maintain in oscillation a piston, and, taking advantage of the law above stated, I connect with said piston, or cause to act upon it, a spring, under such conditions as to automatically regulate the period of the vibration, so that the alternate impulses of the power impelled piston, and the natural vibrations of the spring shall always correspond in direction and coincide in time.

在实施我的发明和实现上述目的的过程中,我利用压力下的蒸汽或气体的能量,通过适当的机械装置,使活塞保持振荡,并利用上述规律,在自动调节振动周期的条件下,我将所述活

塞与一个弹簧连接，或使弹簧作用在活塞上，从而使动力推动活塞的交变脉冲和弹簧的自然振动总是在方向上一致，在时间上重合。

While, in the practice of the invention I may employ any kind of spring or elastic body of which the law or principle of operation above defined holds true, I prefer to use an air spring, or generally speaking a confined body or cushion of an elastic fluid, as the mechanical difficulties in the use of ordinary or metallic springs are serious, owing mainly, to their tendency to break. Moreover, instead of permitting the piston to impinge directly upon such cushions within its own cylinder, I prefer, in order to avoid the influence of the varying pressure of the steam or gas that acts upon the piston and which might disturb the relations necessary for the maintenance of isochronous vibration, and also to better utilize the heat generated by the compression, to employ an independent plunger connected with the main piston, and a chamber or cylinder therefore, containing air which is normally, at the same pressure as the external atmosphere, for thus a spring of practically constant rigidity is obtained, but the air or gas within the cylinder may be maintained at any pressure.

虽然，在本发明的实践中，我可以使用的任何类型的弹簧或弹性体，只要上述定义的操作法则或原理适用，但我更喜欢使用一个空气弹簧，或一般来说一种弹性流体的一个受限体或缓冲垫，因为在使用普通或金属的弹簧的情况下，机械困难是严重的，主要是由于它们的断裂倾向。此外，为了避免作用在活塞上的蒸汽或气体的压力的变化的影响，我宁愿不要让活塞直接撞击它自己气缸内的这种缓冲垫，这样有可能会扰乱用来维持等时振动所必需的关系，并且为了更好地利用由压缩产生的热量，我更喜欢使用与主活塞连接的独立的柱塞，以及由此连接的一个隔室或气缸，这种隔室容纳着与大气压强相同的空气，因此获得了几乎恒定刚度的弹簧，但是气缸内的空气或气体可以保持在任何压力下。

In order to describe the best manner of which I am aware in which the invention is or may be carried into effect, I refer now to the accompanying drawing which represents in central cross-section an engine embodying my improvements.

为了描述我所知道的实施或可能实施本发明的最佳方式，我现在参考附图，该附图在中央横截面中表示了体现我的改进的发动机。

A is the main cylinder in which works a piston B. Inlet ports C C pass through the sides of the cylinder, opening at the middle portion thereof and on opposite sides. Exhaust ports D D extend through the walls of the cylinder and are formed with branches that open into the interior of the cylinder on each side of the inlet ports and on opposite sides of the cylinder.

A 是主气缸，活塞 B 在其中工作。进气口 C C 穿过气缸中部的并且位于气缸对侧的开孔。排气口 D D 延伸穿过气缸壁，并在进气口的每一侧和气缸的相对两侧形成有通向气缸内部的支路。

The piston B is formed with two circumferential grooves E F, which communicate through openings G in the piston with the cylinder on opposite sides of said piston respectively.

活塞 B 形成有两个环状凹槽 E F，它们通过活塞中的开口 G 分别与所述活塞相对两侧的气缸连通。

I do not consider as of special importance the particular construction and arrangement of the cylinder, the piston and the ports for controlling it, except that it is desirable that all the ports, and more especially, the exhaust ports should be made very much larger than is usually the case, so that no force due to the action of the steam or compressed air will tend to retard or affect the return of the piston in either direction.

我并不认为气缸、活塞和控制活塞的端口的具体结构和布置特别重要,只是希望所有的端口,更具体地说,所有排气口应该比通常的情况大得多,这样就不会由于蒸汽或压缩空气的作用而产生倾向于阻碍或影响活塞在任一方向上返回的力。

The piston B is secured to a piston rod H, which works in suitable stuffing boxes in the heads of the cylinder A. This rod is prolonged on one side and extends through bearings V in a cylinder I suitable mounted or supported in line with the first, and within which is a disk or plunger J carried by the rod H.

活塞 B 被固定到活塞杆 H 上,活塞杆 H 在气缸 A 头部的合适的填料函中工作。该杆在一侧被延长并延伸穿过气缸 I 中的轴承 V, 气缸 I 与第一个气缸成直线地被合适安装或支撑,并且在气缸 I 内的是由杆 H 携带的圆盘或柱塞 J。

The cylinder I is without ports of any kind and is air-tight except as a small leakage may occur through the bearings V, which experience has shown need not be fitted with any very considerable accuracy. The cylinder I is surrounded by a jacket K which leaves an open space or chamber around it. The bearings V in the cylinder I, extend through the jacket K to the outside air and the chamber between the cylinder and jacket is made steam or air tight as by suitable packing. The main supply pipe L for steam or compressed air leads into this chamber, and the two pipes that lead to the cylinder A run from the said chamber, oil cups M being conveniently arranged to deliver oil into the said pipes for lubricating the piston.

气缸 I 没有任何类型的端口,并且是气密的,除非通过轴承 V 可能发生小的泄漏,经验表明不需要以非常高的精度装配。气缸 I 被一个夹套 K 包围,夹套 K 在其周围留下一个开放的空间或腔室。气缸 I 中的轴承 V 穿过夹套 K 延伸到外部空气中,并且气缸和夹套之间的腔室通过适当的包装被制成气密的。蒸汽或压缩空气的主供应管 L 通向该腔室,通向气缸 A 的两个管从所述腔室延伸,油杯 M 被方便地设置成将油输送到所述管中以润滑活塞。

In the particular form of engine shown, the jacket K which contains the cylinder I is provided with a flange N by which it is screwed to the end of the cylinder A. A small chamber O is thus formed which has air vents P in its sides and drip pipes Q leading out from it through which the oil which collects in it is carried off.

在所示的特定形式的发动机中,包含气缸 I 的护套 K 设有凸缘 N,通过该凸缘 N,护套 K 被拧到气缸 A 的端部。因此形成了小室 O,该小室在其侧面具有通气孔 P 和从其引出的滴油管 Q,聚集在其中的油通过滴油管 Q 被带走。

To explain now the operation of the device above described. In the position of the parts shown, or when the piston is at the middle point of its stroke, the plunger J is at the center of the cylinder I and

the air on both sides of the same is at the normal pressure of the outside atmosphere. If a source of steam or compressed air be then connected to the inlet ports C C of the cylinder A and a movement be imparted to the piston as by a sudden blow, the latter is caused to reciprocate in a manner well understood. The movement of the piston in either direction ceases when the force tending to impel it and the momentum which it has acquired are counterbalanced by the increasing pressure of the steam or compressed air in that end of the cylinder toward which it is moving and as in its movement the piston has shut off at a given point, the pressure that impelled it and established the pressure that tends to return it, it is then impelled in the opposite direction, and this action is continued as long as the requisite pressure is applied. The movements of the piston compress and rarify the air in the cylinder I at opposite ends of the same alternately. A forward stroke compresses the air ahead of the plunger J which acts as a spring to return it. Similarly on the back stroke the air is compressed on the opposite side of the plunger J and tends to drive it forward. This action of the plunger upon the air contained in the opposite ends of the cylinder is exactly the same in principle as though the piston rod were connected to the middle point of a coiled spring, the ends of which are connected to fixed supports. Consequently the two chambers may be considered as a single spring. The compressions of the air in the cylinder I and the consequent loss of energy due mainly to the imperfect elasticity of the air, give rise to a very considerable amount of heat. This heat I utilize by conducting the steam or compressed air to the engine cylinder through the chamber formed by the jacket surrounding the air-spring cylinder. The heat thus taken up and used to raise the temperature of the steam or air acting upon the piston is availed of to increase the efficiency of the engine. In any given engine of this kind the normal pressure will produce a stroke of determined length, and this will be increased or diminished according to the increase of pressure above or the reduction of pressure below the normal.

现在解释上述设备的运行。在所示部件的位置，或者当活塞处于其冲程的中点时，柱塞J处于气缸I的中心，并且其两侧的空气处于外部大气的正常压力下。如果蒸汽源或压缩空气源连接到气缸A的进气口CC，并通过突然的吹气使活塞运动，活塞就会以一种众所周知的方式往复运动。当倾向于推动活塞的力和它所获得的动量被它所运动朝向的气缸那端的不断增加的蒸汽的或压缩空气的压力所抗衡时，活塞在任一方向上的运动将停止，并且当活塞在运动中停止在给定点时，推动它的压力建立了倾向于退回它的压力，然后它被推向相反的方向，并且只要施加需要的压力，这个动作就继续。活塞的运动在气缸I的相对两端交替压缩和稀薄化气缸I中的空气。一个向前的冲程压缩柱塞J前面的空气，空气作为一个弹簧使柱塞J返回。类似地，在回程中，空气在柱塞J的相对一侧被压缩，并倾向于向前驱动柱塞J。柱塞对被容纳在气缸相对两端的空气的作用在原理上完全相同，就好像活塞杆连接到螺旋弹簧的中点，螺旋弹簧的端部被连接到固定支架上。因此，这两个腔室可以被视为单个弹簧。气缸I中空气的压缩和随后主要由于空气的不完全弹性造成的能量损失，产生了相当大的热量。我将蒸汽或压缩空气通过空气弹簧气缸周围的外套形成的腔室导入发动机气缸中，通过这种方式我利用了这种热量。这样吸收的热量用来提高作用在活塞上的蒸汽或空气的温度，从而提高了发动机的效率。在任何给定的这种发动机中，正常压力将产生一个确定长度的冲程，这将根据高于正常压力的压力增加或低于正常压力的压力减少而增加或减少。

In constructing the apparatus I allow for a variation in the length of stroke by giving to the confining cylinder I of the air spring properly determined dimensions. The greater the pressure upon the piston, the higher will be the degree of compression of the air-spring, and the consequent counteracting force upon the plunger. The rate or period of reciprocation of the piston however is no more dependent upon the pressure applied to drive it, than would be the period of oscillation of a pendulum permanently

maintained in vibration, upon the force which periodically impels it, the effect of variations in such force being merely to produce corresponding variations in the length of stroke or amplitude of vibration respectively. The period is mainly determined by the rigidity of the air spring and the inertia of the moving system, and I may therefore secure any period of oscillation within very wide limits by properly portioning these factors, as by varying the dimensions of the air chamber which is equivalent to varying the rigidity of the spring, or by adjusting the weight of the moving parts. These conditions are all readily determinable, and an engine constructed as herein described may be made to follow the principle of operation above stated and maintain a perfectly uniform period through very much wider limits of pressure than in ordinary use, it is ever likely to be subjected to and it may be successfully used as a prime mover wherever a constant rate of oscillation or speed is required, provided the limits within which the forces tending to bring the moving system to a given position are proportionate to the displacements, are not materially exceeded. The pressure of the air confined in the cylinder when the plunger J is in its central position will always be practically that of the surrounding atmosphere, for while the cylinder is so constructed as not to permit such sudden escape of air as to sensibly impair or modify the action of the air spring there will still be a slow leakage of air into or out of it around the piston rod according to the pressure therein, so that the pressure of the air on opposite sides of the plunger will always tend to remain at that of the outside atmosphere.

在构建该装置时,通过为空气弹簧的限制气缸 I 确定适当的尺寸,为冲程长度的变化提供了适当的余量。活塞上的压力越大,空气弹簧的压缩程度就越高,因此作用在柱塞上的反作用力就越高。然而,活塞往复运动的速率或周期不再取决于所施加的驱动它的压力,这种压力就像钟摆的振荡周期永远保持在振动中一样,而是取决于周期性推动它的力,这种力的变化的效果仅仅是分别产生冲程长度或振动幅度的相应变化。然而,如上所述,活塞往复运动的速率或周期主要由空气弹簧的刚度和运动系统的惯性决定,并且通过适当地调整这些因素的比例,比如通过改变空气腔的尺寸,这相当于改变弹簧的刚度,或者通过调节运动部件的重量,可以确保在非常宽的范围内的任何振动周期。这些条件都是容易确定的,并且如本文所述构造的发动机可以遵循上述运行原理,并且通过比普通使用中的压力限度范围更加宽的压力限度范围来保持完全一致的周期,只要不超过使运动系统运动到给定位置的力与位移成正比的限度,它就有可能经受住并可以成功地用作需要恒定摆动速率或速度的原动机。当柱塞 J 处于其中心位置时,限制在气缸中的空气压力实际上将总是周围大气的压力,因为虽然气缸被构造成不允许空气突然逸出而明显削弱或改变空气弹簧的作用,但是根据其中的压力,空气仍然会在活塞杆周围缓慢地泄漏到气缸中或从气缸中泄漏出来,使得柱塞的对侧的空气压力将总是倾向于保持在外部大气的压力。

As an instance of the uses to which this engine may be applied I have shown its piston rod connected with a pawl R the oscillation of which drives a train of wheels. These may constitute the train of a clock or of any other mechanism. The pawl R is pivoted at R' and its bifurcated end engages with the teeth of the ratchet wheel alternately on opposite sides of the same, one end of the pawl at each half oscillation acting to propel the wheel forward through the space of one tooth when it is engaged and locked by the other end on the last half of the oscillation which brings the first end into position to engage with another tooth.

作为应用这种发动机的一个例子,我已经展示了它的活塞杆与棘爪 R 连接,棘爪 R 的摆动驱动一连串的齿轮。这些齿轮可以构成一个时钟的或任何其他机械装置的齿轮系。棘爪 R 在 R' 处枢转,并且其分叉端交替地与棘轮的齿在相对两侧上啮合,棘爪的一端在每次半个动时

用于推动齿轮向前通过一个齿的空间，当棘爪的另一端在摆动的后半段被啮合和锁定时，这使得第一端进入与另一个齿啮合的位置。

Another application of the invention is to move a conductor in a magnetic field for generating electric currents, and in these and similar uses it is obvious that the characteristics of the engine render it especially adapted for use in small sizes or units.

本发明的另一个应用是在磁场中移动一个导体以产生电流，在这些和类似的应用中，很明显，该发动机的特性使其特别适用于小尺寸或小单元。

Having now described my invention, what I claim is—

现在描述了我的发明，我主张的是—

1. A reciprocating engine comprising in combination, a cylinder, a piston and a spring connected with or acting upon the reciprocating element, the said spring and reciprocating element being related in substantially the manner described so that the forces which tend to bring the reciprocating parts into a given position are proportionate to the displacements, whereby an isochronous vibration is obtained.

1、一种往复式发动机，包括一个气缸；一个活塞和一个弹簧，它们与往复式组件连接或者作用在往复式组件上，所述弹簧和往复式组件基本上以所述方式相关联，使得倾向于使得将往复式部件带入给定位置的力与位移成正比，由此获得等时振动。

2. A reciprocating engine comprising in combination, a cylinder, a piston impelled by steam or gas under pressure, and an air spring maintained in vibration by the movements of the piston, the piston and spring being related in substantially the manner described so that the forces which tend to bring the reciprocating parts into a given position are proportionate to the displacements whereby an isochronous vibration is obtained.

2、一种往复式发动机，包括一个气缸；由处于压力下的蒸汽或气体推动的一个活塞和通过活塞的运动保持振动的一个空气弹簧，活塞和弹簧基本上以所述的方式相关，使得倾向于使得将往复运动部件带到给定位置的力与位移成正比，由此获得等时振动。

3. The combination of a cylinder and a piston adapted to be reciprocated by steam or gas under pressure, a cylinder and a plunger therein reciprocated by the piston and constituting an air spring acting upon said piston, the piston and spring being related in the manner described so that the forces which tend to bring the piston into a given position are proportionate to the displacement whereby an isochronous oscillation of the piston is obtained.

3、一个气缸和一个活塞的组合，适于通过处于压力下的蒸汽或气体来进行往复运动，气缸和气缸中的一个柱塞通过活塞来进行往复运动并构成作用在所述活塞上的空气弹簧，活塞和弹簧以所述方式相关联，使得倾向于使得将往复运动部件带到给定位置的力与位移成正比，由此获得活塞的等时振动。

4. The combination of a cylinder and a piston adapted to be reciprocated by steam or gas under pressure,

a cylinder and piston constituting an air spring connected with the piston, a jacket forming a chamber around the air spring through which the steam or compressed gas is passed on its way to the cylinder, as and for the purpose set forth.

4、一个气缸和一个活塞的组合，适于通过处于压力下的蒸汽或气体来进行往复运动，一个气缸和活塞构成与活塞连接的空气弹簧，围绕空气弹簧形成腔室的一个夹套，蒸汽或压缩气体通过该腔室到达气缸，用于如前所述的目的。

5. The method of producing isochronous movement herein described, which consists in reciprocating a piston by steam or gas under pressure and controlling the rate or period of reciprocation by the vibration of a spring, as set forth.

5、在此描述的产生等时运动的方法，包括通过处于压力下的蒸汽或气体使活塞往复运动，并通过一个弹簧的振动控制往复运动的速率或周期，如前所述。

6. The method of operating a reciprocating engine which consists in reciprocating a piston, maintaining by the movements of the piston, the vibration of an air spring and applying the heat generated by the compression of the spring to the steam or gas driving the piston.

6、运行一个往复式发动机的方法，包括使一个活塞往复运动，通过活塞的运动保持空气弹簧的振动，并将弹簧压缩产生的热量应用于驱动活塞的蒸汽或气体。

NIKOLA TESLA.

尼古拉·特斯拉

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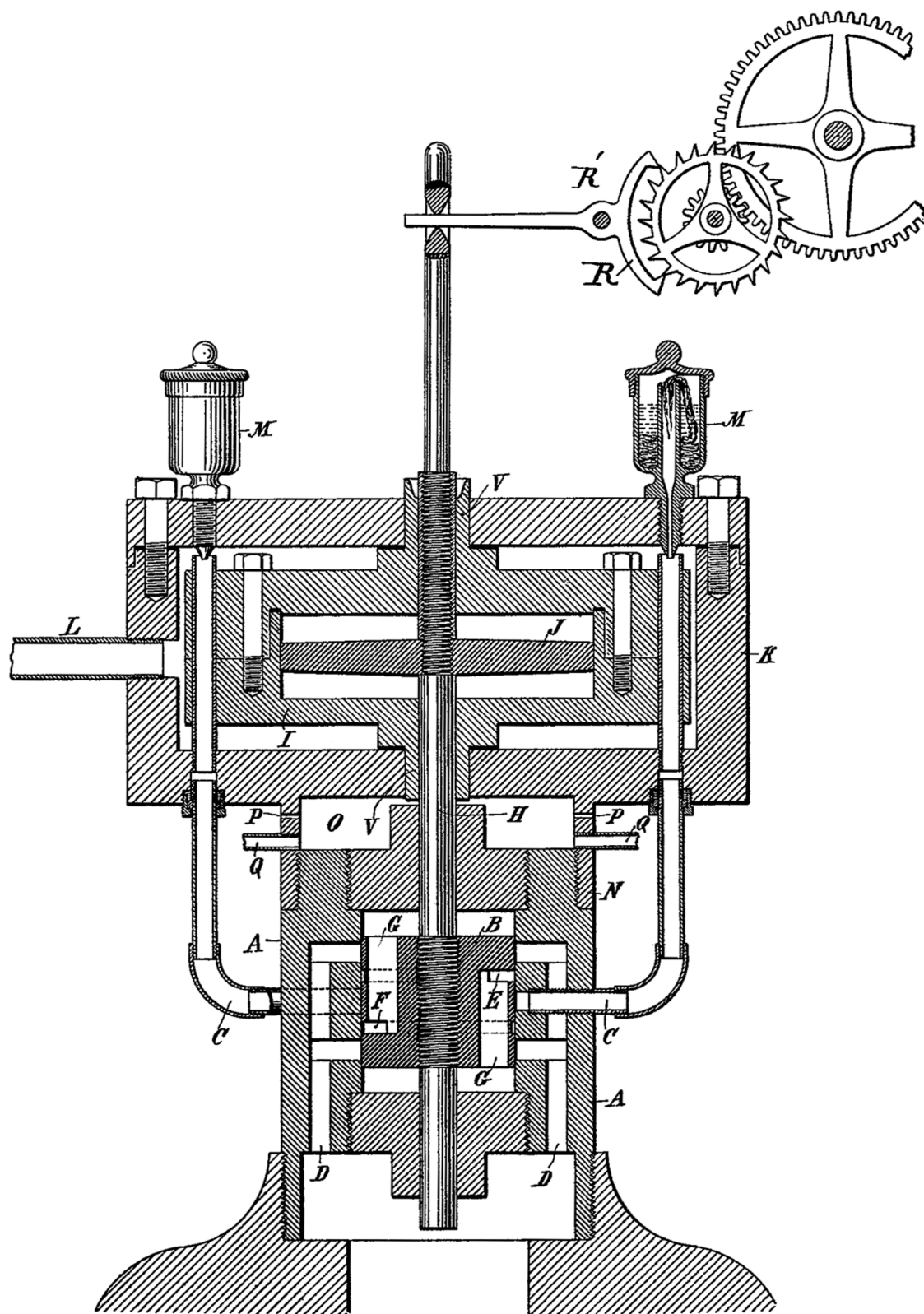
帕克·w·佩奇、R. F.盖洛德。

(No Model.)

N. TESLA.
RECIPROCATING ENGINE.

No. 514,169.

Patented Feb. 6, 1894.



Witnesses
Raphael Netter
R. F. Gaylord

Inventor
Nikola Tesla
By his Attorneys
Duncan & Page.

STEAM-ENGINE.

蒸汽机

NIKOLA TESLA, OF NEW YORK, N. Y.

纽约州纽约市的尼古拉·特斯拉

SPECIFICATION forming part of Letters Patent No. 517,900, dated April 10, 1894.

Application filed December 29, 1893. Serial No. 495,079. (No model.)

该说明书形成了颁发于 1894 年 4 月 10 日编号为 517,900 的专利证书的一部分。

申请于 1893 年 12 月 29 日提交。序列号 495,079。(没有模型)

To all whom it may concern:

致所有有关人士:

Be it known that I, NIKOLA TESLA, a citizen of the United States, residing at New York, in the county and State of New York, have invented certain new and useful Improvements in Steam-Engines, of which the following is a specification, reference being had to the drawings accompanying and forming a part of the same.

众所周知，我，尼古拉·特斯拉，一名美国公民，居住在纽约州纽约郡纽约市，在蒸汽机方面已经发明了某些新的和有用的改进，以下是该发明一个说明书，必须参考随附的图纸，它已形成了该说明书的一部分。

Heretofore, engines, operated by the application of a force such as the elastic tension of steam or a gas under pressure, have been provided with a fly-wheel, or some rotary system equivalent in its effect and possessing relatively great mechanical inertia, which was relied upon for maintaining a uniform speed. I have produced however, an engine which without such appurtenances produces, under very wide variations of pressure, load, and other disturbing causes, an oscillating movement of constant period, and have shown and described the same in an application filed on August 19, 1893, Serial No. 483,563. A description of the principle of the construction and mode of operation of this device is necessary to an understanding of my present invention. When a spring which possesses a sensible inertia is brought under tension as by being stretched and then freed, it will perform vibrations which are isochronous and, as to period, mainly dependent upon the rigidity of the spring and its own inertia or that of the moving system of which it forms an immediate part. This is known to be true in all cases where the force which tends to bring the spring or movable system into a given position is proportionate to the displacement. In utilizing this principle for the purpose of producing reciprocating movement of a constant period, I employ the energy of steam or gas under pressure, acting through proper mechanism, to maintain in oscillation a piston, and connect with or cause to act upon such piston a spring, preferably, an air spring, under such conditions as to automatically regulate the period of the vibration, so that the alternate impulses of the power impelled piston and the natural vibrations of the spring shall always correspond in direction and coincide in time. In such an apparatus it being essential that the inertia of the moving system and the rigidity of the spring should bear certain definite relations, it is obvious that

the practicable amount of work performed by the engine, when this involves the overcoming of inertia is a limitation to the applicability of the engine. I therefore propose, in order to secure all the advantages of such performances as this form of engine is capable of, to utilize it as the means of controlling the admission and exhaust of steam or gas under pressure in other engines generally, but more especially those forms of engine in which the piston is free to reciprocate, or in other words, is not connected with a fly wheel or other like device for regulating or controlling its speed.

迄今为止，由诸如压力下的蒸汽或气体的弹性张力之类的力来运行的发动机，已经配有飞轮或一些等效的旋转系统，并且具有相对较大的机械惯性，这是维持匀速所依赖的。然而，我已经生产了一种发动机，该发动机没有这样的附属物，在压力、负载和其它干扰原因的非常大的变化下，能产生一个恒定周期的振荡运动，并且在 1893 年 8 月 19 日提交的序列号为 483,563 的申请中已经展示和描述了该发动机。对该装置的结构原理和运行模式的描述对于理解本发明是必要的。当一个具有可感知惯性的弹簧受到拉伸，然后被释放，它将执行等时振动，至于周期，主要取决于弹簧的刚度、它自己的惯性或系统的惯性，该弹簧可以形成系统的一个直接部分。众所周知，倾向于将弹簧或可移动系统带到给定位置的力在与位移成正比的所有情况下，这都是正确的。在利用这一原理产生恒定周期的往复运动的过程中，我利用处在压力下的蒸汽的或气体的能量，通过适当的机械装置，使一个活塞维持振荡，并且连接一个或者作用在这样一个弹簧上，最好是一个空气弹簧，在能够自动调节振动周期的条件下，从而使动力推动活塞的交变脉冲和弹簧的自然振动总是在方向上一致，在时间上重合。在这种装置中，至关重要是运动系统的惯性和弹簧的刚度应该具有某些确定的关系，很明显，当这涉及惯性的克服时，由发动机执行的实际工作量是对发动机适用性的限制。因此，为了确保这种形式的发动机所具有的性能的所有优点，我提议将其用作控制其他发动机中的处于压力下的蒸汽或气体的进气和排气的装置，尤其是那些活塞可以自由往复运动的发动机，或者换句话说，它们的活塞不与飞轮或其他用于调节或控制其速度的类似装置连接。

The drawings hereto annexed illustrate devices by means of which the invention may be carried out, Figure 1 being a central vertical section of an engine embodying my invention, and Fig. 2 a similar view of a modification of the same.

附图展示了可以实施本发明的装置，图 1 是体现本发明的发动机的中央垂直截面，图 2 是该发动机的修改的类似视图。

Referring to Fig. 1, A designates a cylinder containing a reciprocating piston B secured to a rod C extending through one or both cylinder heads.

参照图 1，A 表示包含一个往复活塞 B 的一个气缸，活塞 B 被固定到延伸穿过一个或两个气缸盖的杆 C 上。

D D' are steam ducts communicating with the cylinder at or near its ends and E is the exhaust chamber or passage located between the steam ports. The piston B is provided with the usual passages F F' which by the movements of the piston are brought alternately into communication with the exhaust port. G designates a slide valve which when reciprocated admits the steam or the gas by which the engine is driven, from the pipe G' through the ducts D D' to the ends of the cylinder.

D D'是在气缸端部或端部附近与气缸连通的蒸汽导管，E 是位于蒸汽口之间的排气室或通

道。活塞 B 配有惯用的通道 FF', 通过活塞的运动, 这些通道交替地与排气口连通。G 表示一个滑阀, 当滑阀往复运动时, 允许蒸汽或气体从管道 G' 通过导管 D D' 到达气缸的端部, 发动机通过该蒸汽或气体被驱动。

The parts thus described may be considered as exemplifying any cylinder, piston and slide valve with the proper ports controlled thereby, but the slide valve instead of being dependent for its movement upon the piston B is connected in any manner so as to be reciprocated by the piston rod of a small engine of constant period, constructed substantially as follows:—a is the cylinder, in which works the piston b. An inlet pipe c passes through the side of the cylinder at the middle portion of the same. The cylinder exhausts through ports d d' into a chamber d' provided with an opening d". The piston b is provided with two circumferential grooves e, f which communicate through openings g in the same with the cylinder chambers on opposite sides of the piston. The special construction of this device may be varied considerably, but it is desirable that all the ports, and more particularly, the exhaust ports be made larger than is usually done, so that no force due to the action of the steam or compressed air in the chambers will tend to retard or accelerate the movement of the piston in either direction. The piston b is secured to a rod h which extends through the cylinder heads, the lower end carrying the slide valve above described and the upper end having secured to it a plunger j in a cylinder i fixed to the cylinder a and in line with it. The cylinder i is without ports of any kind and is air-tight except that leakage may occur around the piston rod which does not require to be very close fitting, and constitutes an ordinary form of air spring.

如此描述的部件可以被认为是在举例说明任何气缸、活塞和滑阀, 具有该部件控制的适当端口, 但是滑阀不依赖于活塞 B 的运动, 而是以任何方式被连接, 以便由一个活塞杆来进行往复运动, 该活塞杆被连接到具有恒定周期的一个小型发动机上, 基本上构造如下:—a 是气缸, 活塞 b 在其中工作。入口管 c 从气缸的中部穿过气缸的侧面。气缸通过端口 dd 排气到配有开口 d" 的一个腔室 d' 中。活塞 b 配有两个环状沟槽 e f, 它们通过沟槽中的开口 g 与活塞相对两侧的气缸室连通。这种装置的特殊结构可以有很大的变化, 但是希望所有的端口, 更具体地说是排气口比通常的要大, 这样, 这样就不会由于腔室中的蒸汽或压缩空气的作用而产生倾向于阻碍或影响活塞在任一方向上返回的力。活塞 b 被固定在穿过气缸盖的一个杆 h 上, 下端携带有上述滑阀, 上端固定有位于气缸 i 中的柱塞 j, 气缸 i 被固定在气缸 a 上并与其成一条直线。气缸 i 没有任何类型的端口, 并且是气密的, 除了活塞杆周围可能发生泄漏, 这不需要非常紧密的装配, 并且构成一个空气弹簧的普通形式。

If steam or a gas under pressure be admitted through the port c to either side of the piston b, the latter, as will be understood, may be maintained in reciprocation, and it is free to move, in the sense that its movement in either direction ceases only when the force tending to impel it and the momentum which it has acquired are counterbalanced by the increasing pressure of the steam in that end of the cylinder toward which it is moving, and as in its movement the piston has shut off at a given point, the pressure that impelled it and established the pressure that tends to return it, it is then impelled in the opposite direction, and this action is continued as long as the requisite pressure is applied. The movements of the piston compress and rarefy the air in the cylinder i at opposite ends of the same alternately, and this results in the heating of the cylinder. But since a variation of the temperature of the air in the chamber would affect the rigidity of the air spring, I maintain the temperature uniform as by surrounding the cylinder i with a jacket a' which is open to the air and filled with water.

如果处于压力下的蒸汽或气体通过端口 c 进入活塞 b 的任一側，可以理解的是，活塞 b 可以保持往复运动，并且可以自由移动，从这个意义上说，只有当推动它的力和它所获得的动量被它的运动所朝向的气缸那端的不断增加的蒸汽压力所抗衡时，活塞在任一方向上的运动将停止，并且当活塞在运动中停止在给定点时，推动它的压力建立了倾向于退回它的压力，然后它被推向相反的方向，并且只要施加需要的压力，这个动作就继续。活塞的运动在气缸 i 的相对两端交替地压缩和稀薄化气缸 i 中的空气，这导致气缸的加热。但是由于室内空气温度的变化会影响空气弹簧的刚度，所以我用一个向空气敞开并充满水的夹套 a' 包围气缸 i，以保持温度均匀。

In such an engine as that just above described the normal pressure will produce a stroke of determined length, which may be increased or diminished according to the increase of pressure above or the reduction of pressure below the normal and due allowance is made in constructing the engine for a variation in the length of stroke. The rate or period of reciprocation of the piston, however, is no more dependent upon the pressure applied to drive it, than would be the period of oscillation of a pendulum permanently maintained in vibration, upon the force which periodically impels it, the effect of variations in such force being merely to produce corresponding variations in the length of stroke or amplitude of vibration respectively. The period is mainly determined by the rigidity of the air spring and the inertia of the moving system and I may therefore secure any period of oscillation within very wide limits by properly proportioning these factors, as by varying the dimensions of the air chamber which may be equivalent to varying the rigidity of the spring, or by adjusting the weight of the moving parts. This latter is readily accomplished by making provision for the attachment to the piston rod of one or more weights h'. Since the only work which the small engine has to perform is the reciprocation of the valve attached to the piston rod, its load is substantially uniform and its period by reason of its construction will be constant. Whatever may be the load on the main engine therefore the steam is admitted to the cylinder at defined intervals, and thus any tendency to a change of the period of vibration in the main engine is overcome.

在如上所述的这种发动机中，正常压力将产生确定长度的冲程，该冲程可以根据高于正常压力的压力增加或低于正常压力的压力减少而增加或减少，并且在构造发动机时考虑到冲程长度的变化。然而，活塞往复运动的速率或周期不再取决于所施加的驱动它的压力，也不再取决于持续振动的钟摆的振荡周期，而是取决于周期性推动它的力，这种力的变化的效果仅仅是分别产生冲程长度或振幅的相应变化。周期主要由空气弹簧的刚度和运动系统的惯性决定，因此，通过适当地调整这些因素的比例，例如通过改变空气腔室的尺寸（这相当于改变弹簧的刚度），或者通过调节运动部件的重量，可以在很宽的范围内保证任何振动周期。后者很容易通过在活塞杆上安装一个或多个重物 h' 来实现。由于小型发动机必须做的唯一工作是连接在活塞杆上的阀门的往复运动，因此它的负载基本上是不变的，并且由于它的结构，其周期将是恒定的。因此，无论主发动机上的负载是多少，蒸汽都以规定的时间间隔进入气缸，从而克服了主发动机振动周期的任何变化趋势。

The control of the main engine by the engine of constant period may be effected in other way—of which Fig. 2 will serve as an illustration. In this case the piston of the controlling engine constitutes the slide valve of the main engine, so that the latter may be considered as operated by the exhaust of the former. In the figure I have shown two cylinders A A' placed end to end with a piston B and B' in each. The cylinder of the controlling engine is formed by or in the casing intermediate to the two main cylinders but in all other essential respects the construction and mode of operation of the controlling

engine remains as described in connection with Fig. 1. The exhaust ports d d however, constitute the inlet ports of the cylinders A A' and the exhaust of the latter is effected through the ports m, m which are controlled by the pistons B and B' respectively. The inlet port for the admission of the steam to the controlling engine is similar to that in Fig. 1 and is indicated by the dotted circle at the center of the piston b.

恒定周期的发动机对主发动机的控制可以以其他方式实现——图 2 将作为其说明。在这种情况下，控制发动机的活塞构成主发动机的滑阀，因此后者可以被认为是由前者的排气来操作的。在图中，我已经展示了两个气缸 A A' 首尾相连放置，每个气缸中有一个活塞 B 和 B'。控制发动机的气缸由两个主气缸之间的壳体形成或在该壳体中形成，但是在所有其他重要的方面，控制发动机的结构和运行模式保持如图 1 所述。然而，排气口 d d 构成气缸 A A' 的进气口，气缸 A A' 的排气通过分别由活塞 B 和 B' 控制的排气口 m m 来进行。蒸汽进入控制发动机的入口，类似于图 1 中的入口，由活塞 b 中心的虚线圆表示。

An engine of the kind described possesses many and important advantages. A much more perfect regulation and uniformity of action is secured, while the engine is simple and its weight for a given capacity is very greatly reduced. The reciprocating movement of the piston may be converted, by the ordinary mechanisms into rotary motion or it may be utilized and applied in any other manner desired, either directly or indirectly.

所描述的这种发动机具有许多重要的优点。确保了更完美的调节和动作的一致性，同时发动机是简单的，并且对于给定的容量，其重量大大降低。活塞的往复运动可以通过普通的机械装置转换成旋转运动，或者可以以任何其它期望的方式直接或间接地利用和应用。

In another application of even date herewith I have shown and described two reciprocating engines combined in such manner that the movement or operation of one is dependent upon and controlled by the other. In the present case, however, the controlling engine is not designed nor adapted to perform other work than the regulation of the period of the other, and it is moreover an engine of defined character which has the capability of an oscillating movement of constant period.

在与此申请同日提交的另一个申请中，我已经展示并描述了两个往复式发动机，它们以这样的方式组合，使得一个发动机的运动或运行依赖于另一个发动机并由另一个发动机控制。然而，在这种情况下，控制发动机并没有被设计成也不适合于执行除了调节另一个发动机的周期之外的其他工作，而且它是一个具有确定特征的发动机，具有恒定周期的一个振荡运动的能力。

What I claim is—

我主张的是—

1. The combination with the cylinder and reciprocating piston and controlling valve of an engine adapted to be operated by steam or a gas under pressure of an independently controlled engine of constant period operating the said valve, as described.

1、气缸、往复式活塞和发动机控制阀的组合，适于由处在具有恒定周期且被独立控制的发

动机的压力下的操作着所述阀门的蒸汽或气体来运行，如所述。

2. The combination of an engine cylinder, a piston adapted to reciprocate therein, a slide valve for controlling the admission of steam to said cylinder, and an independently controlled engine of constant period operatively connected with said valve.

2、一个组合，包括：一个发动机气缸；适于在其中往复运动的一个活塞；用于控制蒸汽进入所述气缸的一个滑阀；以及与所述滑阀可操作性地连接并具有恒定周期的被独立控制发动机。

3. The combination with the cylinder, piston and valve mechanism of a main or working engine, of an independent controlling engine comprising a cylinder, a piston connected with the valve mechanism of the main engine, and a spring acting upon the said piston and controlling the period of its reciprocation, as set forth.

3、一个组合，包括：一个主发动机或工作发动机的缸、活塞和阀门机械装置；一个独立控制发动机包括一个缸、与主发动机的气门机械装置连接的活塞和作用在所述活塞上并控制其往复运动周期的弹簧，如前所述。

4. The combination with a cylinder and a piston adapted to be reciprocated by steam or a gas under pressure of a cylinder and a plunger therein reciprocated by the piston and constituting with its cylinder an air spring, and an open jacket or receptacle around the said cylinder and containing water to preserve the temperature of the air spring uniform, as set forth.

4、一个组合，包括：一个缸和一个适于在缸压力下由蒸汽或气体作用产生往复运动的活塞；以及一个在缸中承受活塞的往复运动并与活塞的缸一起构成空气弹簧的柱塞；以及一个围绕所述缸并装有水以保持空气弹簧温度不变的开口的夹套或容器，如前所述。

5. The combination with a cylinder, a reciprocating piston and valve mechanism for controlling the admission and exhaust of the steam or gas under pressure, of a cylinder, a piston connected with and operating said valve mechanism, and an air spring vibrated by the piston, the spring and piston being related in substantially the manner described to produce a reciprocating movement of constant period.

5、一个组合，包括：一个缸；一个往复运动的活塞和阀门结构，用于控制缸内的处于压力下的蒸汽或气体的进入和排出；一个与所述阀门结构连接并操作所述阀门装置的活塞；以及一个由活塞振动的空气弹簧，弹簧和活塞基本上以所述方式相关联，以产生周期恒定的往复运动。

NIKOLA TESLA.

尼古拉·特斯拉

Witnesses:

ARTHUR H. SMITH,

ERNEST HOPKINSON.

见证人:

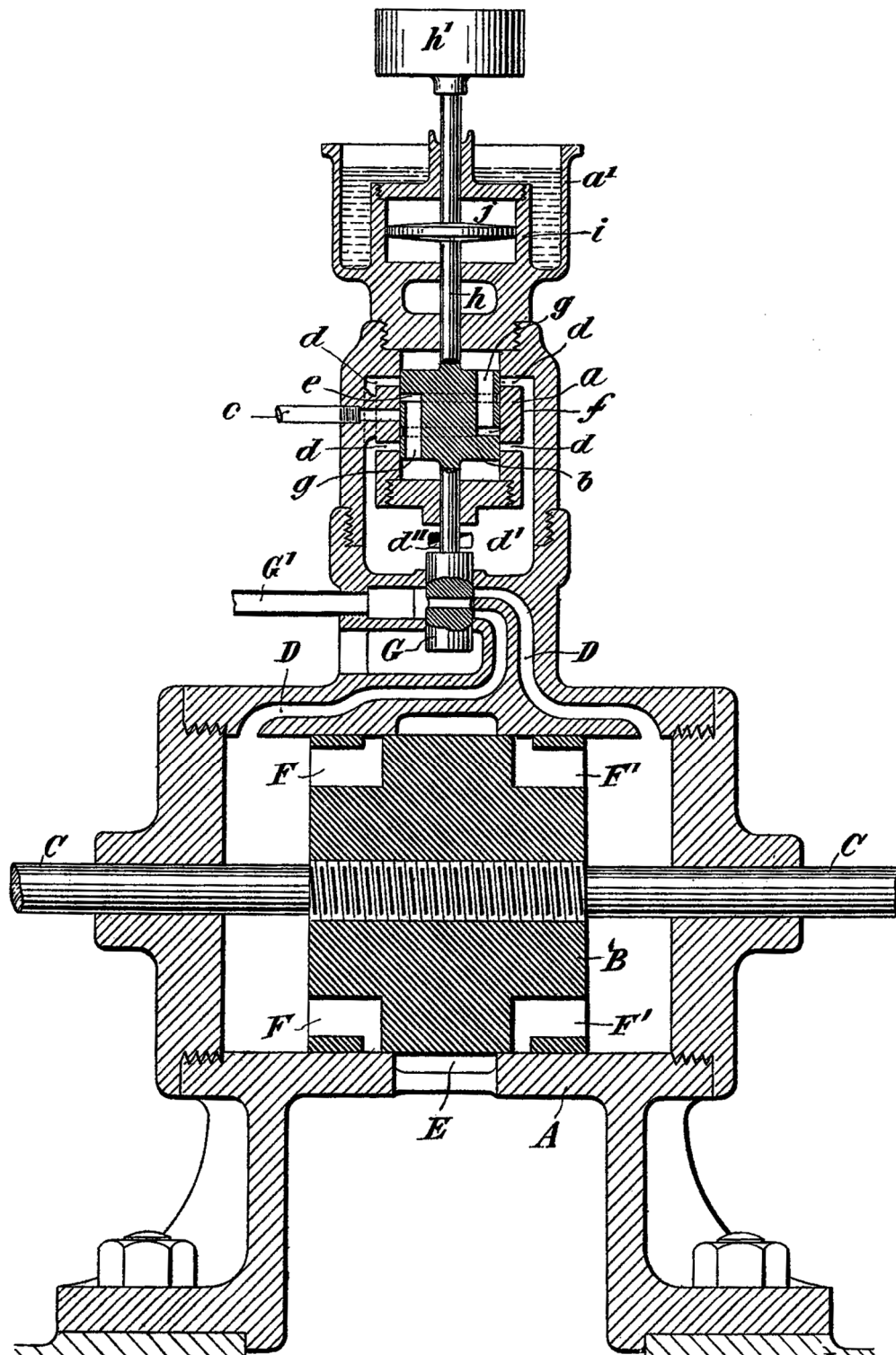
阿瑟·H·史密斯、欧内斯特·霍普金森。

N. TESLA.
STEAM ENGINE.

No. 517,900.

Patented Apr. 10, 1894.

Fig. 1



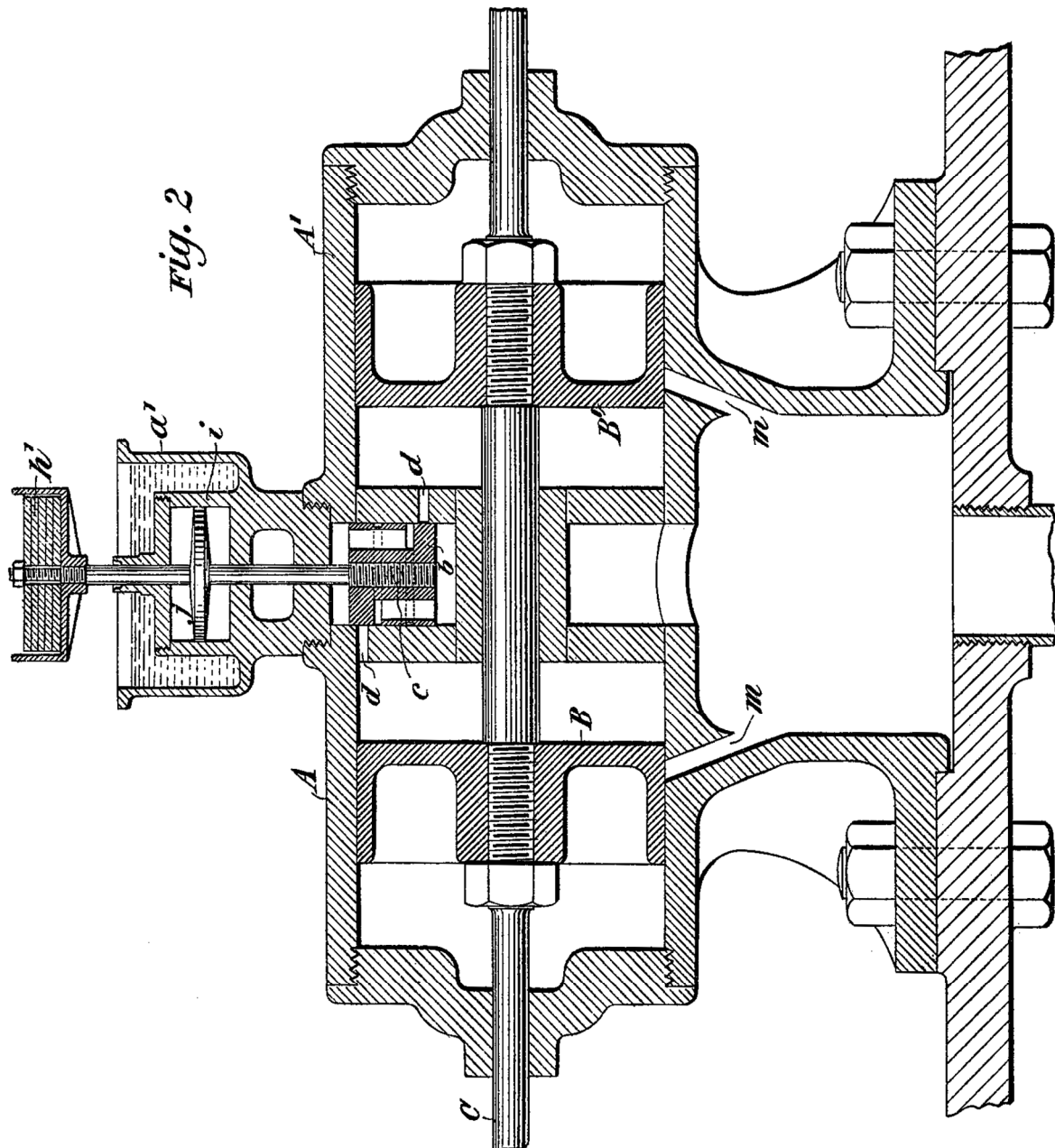
Witnesses:
Raphaël Netter
Ernst Hopkinson

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Nikola Tesla
by *Dureau & Page*
Attorneys.

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STEAM ENGINE.

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Genet Hopkinson

Inventor
Nikola Tesla
by Duncan & Page
Attorneys.

THERMO-MAGNETIC MOTOR.

热磁电动机

NIKOLA TESLA, OF SMILJAN, LIKA, AUSTRIA-HUNGARY.

奥匈帝国利卡县史密里安村的尼古拉·特斯拉

SPECIFICATION forming part of Letters Patent No. 396,121, dated January 15, 1889.

Application filed March 30, 1886. Serial No. 197,115. (No model.)

该说明书形成了颁发于 1889 年 1 月 15 日编号为 396,121 的专利证书的一部分。

申请于 1886 年 3 月 30 日提交。序列号为 197,115。(没有模型)

To all whom it may concern:

致所有相关人士:

Be it known that I, NIKOLA TESLA, of Smiljan, Lika, border country of Austria-Hungary, have invented an Improvement in Thermo-Magnetic Motors, of which the following is a specification.

众所周知，我、尼古拉·特斯拉、来自奥匈帝国边境地区的利卡县的史密里安村，在热磁电动机方面已经发明了一个改进，以下是该发明一个说明书。

It is well known that heat applied to a magnetized body will lessen the magnetism, and if the temperature is raised sufficiently the magnetism will be neutralized or destroyed.

众所周知，加热一个被磁化的物体会减弱其磁性，如果温度升得足够高，磁性就会被抵消或被破坏。

In my present invention I obtain mechanical power by a reciprocating action resulting from the joint operations of heat, magnetism, and a spring or weight or other force—that is to say, I subject a body magnetized by induction or otherwise to the action of heat until the magnetism is sufficiently neutralized to allow a weight or spring to give motion to the body and lessen the action of the heat, so that the magnetism may be sufficiently restored to move the body in the opposite direction, and again subject the same to the demagnetizing of the heat.

在我的发明中，我通过一个往复运动获得机械动力，该往复运动由热、磁、弹簧或重量或其他力的联合行动产生——也就是说，我使得通过感应或其他方式而被磁化的物体受到热的作用，直到磁性被充分抵消，以允许重量或弹簧使物体运动并减少热的作用，从而磁性可以被充分恢复以使物体在相反方向上运动，并再次使物体受到加热的退磁。

In carrying out my invention I am able to make use of either an electro-magnet or a permanent magnet, and I preferably direct the heat against a body that is magnetized by induction, rather than directly against a permanent magnet, thereby avoiding the loss of magnetism that might result in the permanent

magnet by the action of heat. I also provide for lessening the volume of the heat or for intercepting the same during that portion of the reciprocation in which the cooling action takes place.

在实施我的发明时，我能够利用一个电磁体或一个永磁体，并且我首选地将热量导向通过被感应磁化的物体，而不是直接导向永磁体，从而避免可能导致永磁体由于热的作用而失去磁性。在往复运动中发生冷却作用的那一部分，我还提供了减少热量或截断热量的措施。

In the drawings I have represented by diagrams some of the numerous arrangements that may be made use of in carrying out my invention. In all of these figures the magnet-poles are marked N S, the armature A, the Bunsen burner or other source of heat H, the axis of motion M, and the spring or the equivalent thereof—namely, a weight—is marked W.

在附图中，我已经用示意图表示了在实施我的发明中可以利用的许多布置中的一些。在所有这些图中，磁极标记为 N S、衔铁标记为 A、本生灯或其他热源标记为 H、运动轴 M 和弹簧或其等效物（即重物）标记为 W。

In Figure 1 the permanent magnet N is connected with a frame, F, supporting the axis M, from which the arm P hangs, and at the lower end of which the armature A is supported. The stops 2 and 3 limit the extent of motion, and the spring W tends to draw the armature A away from the magnet N. It is now to be understood that the magnetism of N is sufficient to overcome the spring W and draw the armature A toward the magnet N. The heat acting upon the armature A neutralizes its induced magnetism sufficiently for the spring W to draw the armature A away from the magnet N and also from the heat at H. The armature now cools and the attraction of the magnet N overcomes the spring W and draws the armature A back again above the burner H, so that the same is again heated and the operations are repeated. The reciprocating movements thus obtained are employed as a source of mechanical power in any desired manner. Usually a connecting-rod to a crank upon a fly-wheel shaft will be made use of, as indicated in Fig. 10; but I do not limit myself in this respect.

在图 1 中，永磁体 N 与支撑着轴 M 的框架 F 连接，臂 P 悬挂在框架 F 上，衔铁 A 被支撑在框架 F 的下端。止动件 2 和 3 限制运动的范围，弹簧 W 倾向于将衔铁 A 拉离磁体 N。现在可以理解，N 的磁性足以克服弹簧 W 并将衔铁 A 拉向磁体 N。作用在衔铁 A 上的热量足以抵消其感应磁性，使弹簧 W 将衔铁 A 从磁铁 N 和热源 H 处吸走。衔铁现在冷却，磁体 N 的吸引力克服弹簧 W，将衔铁 A 再次拉回到燃烧器 H 上方，使得衔铁再次被加热，并且重复操作。如此获得的往复运动以任何期望的方式被用作机械动力源。通常使用连接着飞轮轴上曲柄的连杆，如图 10 所示；但我并不局限于此。

Fig. 2 represents the same parts as before described; but an electro-magnet is illustrated in place of a permanent magnet. The operations, however, are the same.

图 2 表示与前述相同的部件；但是所示的电磁铁代替了永久磁铁。然而，运行是相同的。

In Fig. 3 I have shown the same parts as in Figs. 1 and 2, only they are differently arranged. The armature A, instead of swinging, is stationary and held by an arm, P', and the core N S of the electro-magnet is made to swing within the helix Q, the said core being suspended by the arm P from the pivot M. A shield, R, is connected with the magnet-core and swings therewith, so that after the heat has

demagnetized the armature A to such an extent that the spring W draws the core N S away from the armature A the shield R comes between the flame H and armature A, thereby intercepting the action of the heat and allowing the armature to cool, so that the magnetism, again preponderating, causes the movement of the core N S toward the armature A and the removal of the shield R from above the flame, so that the heat again acts to lessen or neutralize the magnetism. A rotary or other movement may be obtained from this reciprocation.

在图 3 中，我已经展示了与图 1 和图 2 中相同的部件，只是它们的布局不同。衔铁 A 不是摆动的，而是静止的，并且由臂 P' 夹持，并且使电磁体的铁芯 N S 在螺旋 Q 内摆动，所述铁芯由臂 P 从枢轴 M 悬挂。一个挡板 R 与磁芯连接并随其摆动，从而在热源使衔铁 A 退磁到弹簧 W 将磁芯 N 从衔铁 A 上拉开的程度后，挡板 R 来到火焰 H 和衔铁 A 之间，从而阻止热量的作用并使衔铁冷却，从而磁性再次占优势，导致铁芯 N S 向衔铁 A 移动，并将挡板 R 从火焰上方移开，因此热量再次起到减弱或抵消磁性的作用。从这种往复运动中可以获得旋转或其他运动。

Fig. 4 corresponds in every respect with Fig. 3, except that a permanent horseshoe-magnet, N S, is represented as taking the place of the electro-magnet in said Fig. 3.

图 4 在各方面都对应于图 3，除了一个永久马蹄形磁体 N S 被表示为代替所述图 3 中的电磁体。

In Fig. 5 I have shown a helix, Q, with an armature adapted to swing toward or from the helix. In this case there may be a soft-iron core in the helix, or the armature may assume the form of a solenoid-core, there being no permanent core within the helix.

在图 5 中，我已经展示了一个螺旋 Q，具有一个衔铁，适于朝向或远离该螺旋摆动。在这种情况下，螺旋中可以有一个软铁芯，或者衔铁可以采取一个螺线管铁芯的形式，在螺旋中没有永久的铁芯。

Fig. 6 is an end view, and Fig. 7 a plan view, illustrating my improvement as applied to a swinging armature, A, and a stationary permanent magnet, N S. In this instance I apply the heat to an auxiliary armature or keeper, T, which is adjacent to and preferably in direct contact with the magnet. This armature T, in the form of a plate of sheet-iron, extends across from one pole to the other and is of sufficient section to practically form a keeper for the magnet, so that when this armature T is cool nearly all the lines of force pass over the same and very little free magnetism is exhibited. Then the armature A, which swings freely on the pivots M in front of the poles N S, is very little attracted and the spring s pulls the same away from the poles into the position indicated in the drawings. The heat is directed upon the iron plate T at some distance from the magnet, so as to allow the magnet to be kept comparatively cool. This heat is applied beneath the plate by means of the burners H, and there is a connection from the armature A or its pivot to the gas-cock 6 or other device for regulating the heat. The heat acting upon the middle portion of the plate T, the magnetic conductivity of the heated portion is diminished or destroyed, and a great number of the lines of force are deflected over the armature A, which is now powerfully attracted and drawn into line, or nearly so, with the poles N S. In so doing the cock 6 is nearly closed and the plate T cools, the lines of force are again deflected over the same, the attraction exerted upon the armature A is diminished, and the spring W pulls the same away from the

magnet into the position shown by full lines, and the operations are repeated. The arrangement shown in Fig. 6 has the advantages that the magnet and armature are kept cool and the strength of the permanent magnet is better preserved, as the magnetic circuit is constantly closed.

图 6 是一个端视图，图 7 是一个平面图，展示了我的应用于摆动衔铁 A 和静止永磁体 NS 的改进。在这种情况下，我将热源应用于一个辅助衔铁或看守器 T，该看守器 T 邻近磁体并且首选地与磁体直接接触。这个衔铁 T，是薄铁皮的一块板的形式，从一个磁极延伸到另一个磁极，并且具有足够的截面，以实际上形成磁体的看守器，因此当这个衔铁 T 冷却时，几乎所有的磁力线都经过该衔铁 T，并且表现出非常小的自由磁性。然后，在磁极 NS 前面的枢轴 M 上自由摆动的衔铁 A 几乎不被吸引，并且弹簧 S 将衔铁 A 拉离磁极进入图中所示的位置。热量被引导到离磁体一定距离处的铁板 T 上，从而允许磁体保持相对冷却。这种热量通过燃烧器 H 施加在板的下面，并且从衔铁 A 或其枢轴到燃气旋塞 6 或其它用于调节热量的装置有一个连接。热量作用在板 T 的中间部分，被加热部分的导磁率减少或破坏，大量的磁力线转向衔铁 A，衔铁 A 现在被强有力地吸引并拉成与磁极 NS 成一条线，或几乎如此。在这样做时，旋塞 6 几乎关闭，板 T 冷却，磁力线再次转向板 T，施加在衔铁 A 上的吸引力减小，弹簧 W 将衔铁从磁铁上拉开到实线所示的位置，并重复上述操作。图 6 所示的布置的优点在于，磁体和衔铁保持冷却，并且永磁体的强度得到更好的保持，因为磁路一直是闭合的。

In the plan view, Fig. 8, I have shown a permanent magnet and keeper-plate, T, similar to those in Figs. 6 and 7, with the burners H for the gas beneath the same; but the armature is pivoted at one end to one pole of the magnet and the other end swings toward and from the other pole of the magnet. The spring W acts against a lever-arm that projects from the armature, and the supply of heat has to be partly cut off by a connection to the swinging armature, so as to lessen the heat acting upon the keeper-plate when the armature A has been attracted.

在图 8 的平面图中，我已经展示了类似于图 6 和图 7 中的永磁体和看守板 T，其下方具有使用燃气的燃烧器 H；但是衔铁在一端被枢接到磁体的一个极，而另一端朝向和远离磁体的另一个极摆动。弹簧 W 作用在从衔铁伸出的一个杠杆臂上，并且必须通过与摆动衔铁的一个连接来部分地切断热量供应，以便在衔铁 A 被吸引时减少作用在看守板上的热量。

Fig. 9 is similar to Fig. 8, except that the keeper T is not made use of and the armature itself swings into and out of the range of the intense action of the heat from the burner H.

图 9 类似于图 8，除了没有使用看守器 T，并且衔铁本身摆动到燃烧器 H 的强烈热作用的范围之内和之外

Fig. 10 is a diagram similar to Fig. 1, except that in place of using a spring and stops the armature is shown as connected by a link, 12, to the crank 13 of a fly-wheel, so that the fly-wheel will be revolved as rapidly as the armature can be heated and cooled to the necessary extent. A spring may be used in addition, as in Fig. 1.

图 10 是类似于图 1 的示意图，除了代替使用一个弹簧和多个止动件，衔铁被显示为通过连杆 12 连接到一个飞轮的曲柄 13，从而飞轮将随着衔铁被加热和冷却到必要的程度而快速旋转。如图 1 所示，可以另外使用弹簧。

In Fig. 11 the two armatures A A are connected by a link, so that one will be heating while the other is cooling, and the attraction exerted to move the cooled armature is availed of to draw away the heated armature instead of using a spring.

在图 11 中，两个衔铁 A A 由一个连杆连接，使得一个衔铁将被加热，而另一个衔铁将被冷却，并且被施加的来移动被冷却的衔铁的吸引力被用来抽走被加热的衔铁，而不是使用弹簧。

I have shown in the drawings several ways of carrying out my invention; but said invention is not limited by any particular form, arrangement, or construction of devices.

我已经在附图中展示了实现我的发明的几种方式；但是所述发明不受设备的任何特定形式、布置或构造的限制。

I claim as my invention—

我声称这是我的发明—

1. The combination, with a swinging body under the influence of magnetism, of a burner or other source of heat acting to vary the magnetism, and a spring or other power to move the swinging body in the opposite direction to the action of the magnetism, substantially as set forth.

1、一个组合，它包括：在磁性影响下的摆动体；燃烧器或其它用于改变磁性的热源；以及弹簧或其它用于使摆动体在与磁性作用相反的方向上运动的动力，基本上如前所述。

2. The combination, with two or more armatures connected to each other, of magnets to influence such armatures, and burners or other sources of heat to vary the magnetic action and cause the armatures to move, substantially as set forth.

2、一个组合，它包括：两个或多个彼此连接的衔铁；影响这种衔铁的磁体；以及改变磁作用并导致衔铁移动的燃烧器或其他热源，基本上如所述。

Signed by me this 29th day of March, 1886.

由我于 1886 年 3 月 29 日签署。

NIKOLA TESLA.

尼古拉·特斯拉

Witnesses:

GEO. T. PINCKNEY,

WALLACE L. SERRELL.

见证人:

杰奥·T·平克尼、华莱士·塞雷尔。

(No Model.)

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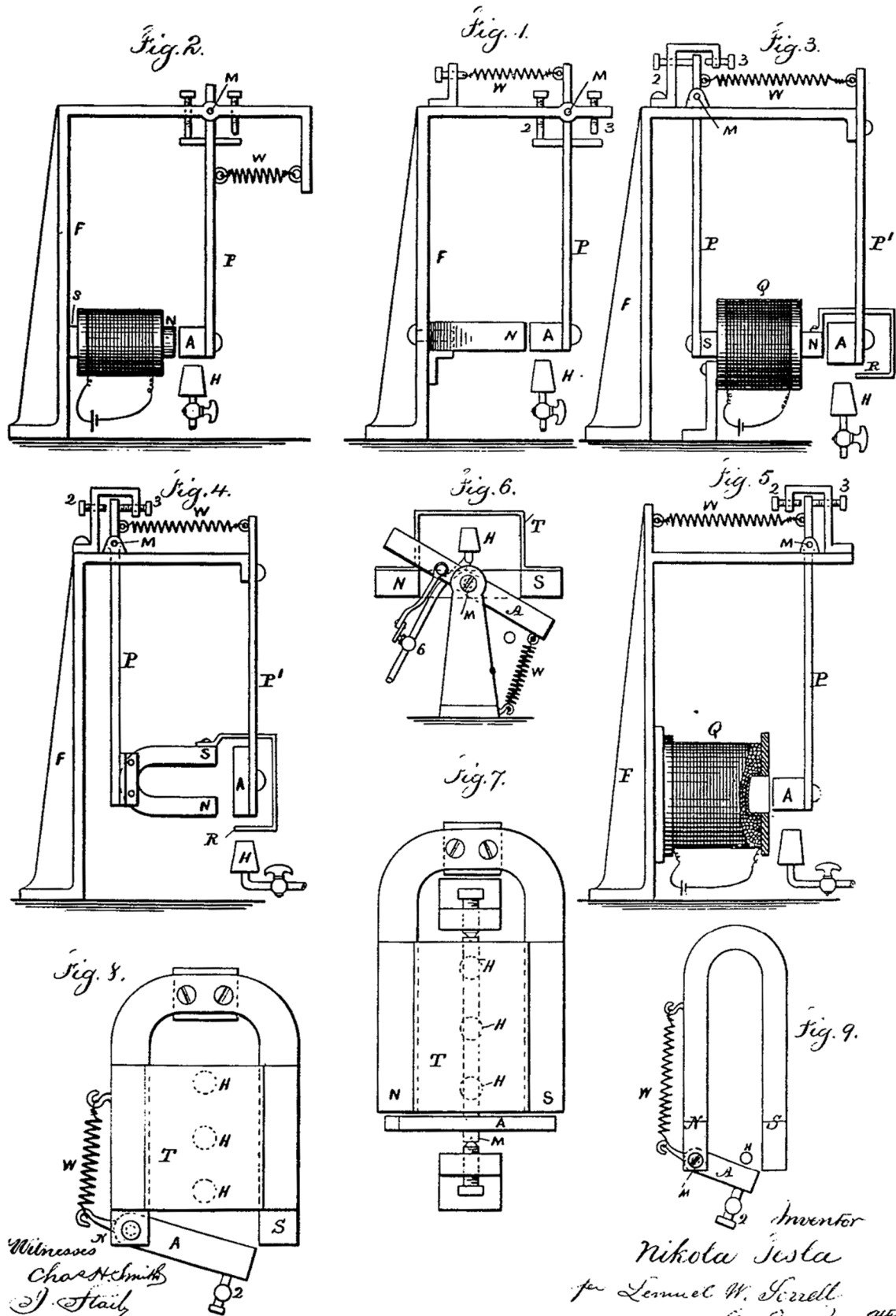
2 Sheets—Sheet 1.

N. TESLA.

THERMO MAGNETIC MOTOR.

No. 396,121.

Patented Jan. 15, 1889.



(No Model.)

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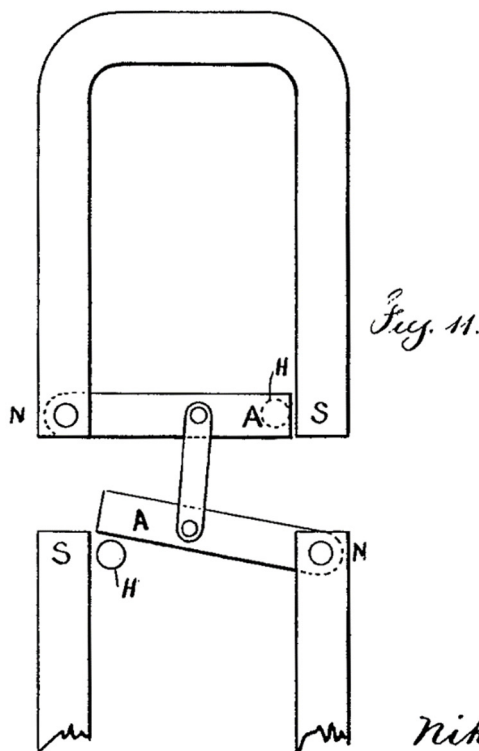
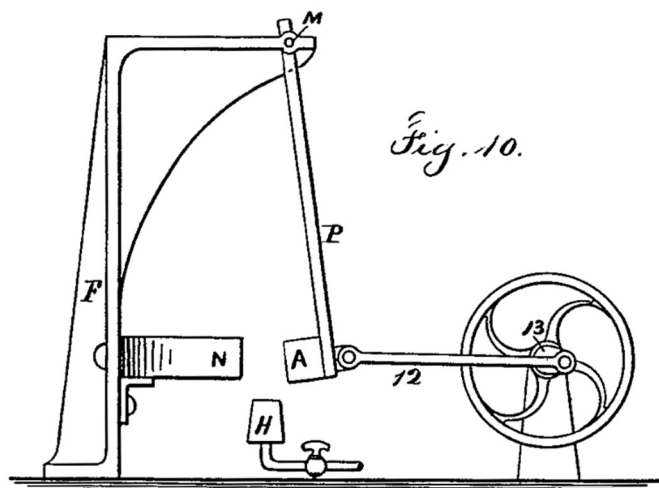
2 Sheets—Sheet 2.

N. TESLA.

THERMO MAGNETIC MOTOR.

No. 396,121.

Patented Jan. 15, 1889.



Witnesses

Char H. Smith
J. Stail,

Inventor

Nikola Tesla
for Lemuel W. Serrell atty

PYROMAGNETO-ELECTRIC GENERATOR.

热磁电发电机

NIKOLA TESLA, OF NEW YORK, N.Y., ASSIGNOR OF ONE-HALF TO CHARLES F.
PECK, OF ENGLEWOOD, NEW JERSEY.

纽约州纽约市的尼古拉·特斯拉将一半专利权转让给
新泽西州恩格尔伍德市的查尔斯·F·佩克。

SPECIFICATION forming part of Letters Patent No. 428,057, dated May 13, 1890.
Original application filed May 26, 1887; Serial No. 239,481. Divided and this application filed May 25,
1889. Serial No. 312,069. (No model.)

该说明书形成了颁发于 1890 年 5 月 13 日编号为 428,057 的专利证书的一部分。
原始申请于 1887 年 5 月 26 日提交，序列号 239,481。原始申请于 1889 年 5 月 25 日被分立
并被提交。序列号 312,069。(没有模型)

To all whom it may concern:

致所有相关人士:

Be it known that I, NIKOLA TESLA, a subject of the Emperor of Austria-Hungary, from Smiljan, Lika, border country of Austria-Hungary, residing at New York, in the county and State of New York, have invented certain new and useful Improvements in Electric Generators, of which the following is a specification.

众所周知，我、尼古拉·特斯拉、一位奥匈帝国的臣民，来自奥匈帝国边境地区的利卡县的史密里安村，居住在纽约州纽约郡纽约市，在发电机方面已经发明了某种新的和有用的改进，以下是该发明一个说明书。

This application is a division of an application filed by me May 26, 1887, Serial No. 239,481.

本申请是本人于 1887 年 5 月 26 日提交的序列号为 239,481 的申请的分立。

This invention is an improved form of electrical generator based upon the following well-known laws:

本发明是基于以下众所周知的规律的发电机的改进形式:

First, that electricity or electrical energy is developed in any conducting-body by subjecting such body to a varying magnetic influence, and, second, that the magnetic properties of iron or other magnetic substance may be partially or entirely destroyed or caused to disappear by raising it to a certain temperature, but restored and caused to reappear by again lowering its temperature to a certain degree.

第一，通过使任何导体受到一个变化的磁影响，可以在任何导体中产生电或电能；第二，铁或其他磁性物质的磁属性可以通过升高到一定温度而部分地或全部地被破坏或消失，但通过再次降低其温度到一定程度而恢复并重新出现。

These laws may be applied in the production of electrical currents in many ways, the principle of which is in all cases the same—viz., to subject a conductor to a varying magnetic influence, producing such variations by the application of heat, or, more strictly speaking, by the application or action of a varying temperature upon the source of the magnetism.

这些规律可以以多种方式应用于电流的产生，其原理在所有情况下都是相同的，也就是使导体受到变化的磁影响，通过加热的应用，或者更严格地说，通过一个变化的温度在磁源上的应用或作用来产生这种变化。

This principle of operation may be illustrated by a simple experiment: Place end to end, and preferably in actual contact, a permanently-magnetized steel bar and a strip or bar of soft iron. Around the end of the iron bar or plate wind a coil of insulated wire. Then apply to the iron between the coil and the steel bar a flame or other source of heat which will be capable of raising that portion of the iron to an orange-red, or a temperature of about 600° centigrade. When this condition is reached, the iron somewhat suddenly loses its magnetic properties, if it be very thin, and the same effects produced as though the iron had been moved away from the magnet or the heated section had been removed. This change of condition, however, is accompanied by a shifting of the magnetic lines, or, in other words, by a variation in the magnetic influence to which the coil is exposed, and a current in the coil is the result. Then remove the flame or in any other way reduce the temperature of the iron. The lowering of its temperature is accompanied by a return of its magnetic properties, and another change of magnetic conditions occurs, accompanied by a current in an opposite direction in the coil. The same operation may be repeated indefinitely, the effect upon the coil being similar to that which would follow from moving the magnetized bar to and from the end of the iron bar or plate.

这个运行原理可以通过一个简单的实验来说明：将一根永久磁化的钢条和一根软铁条或软铁棒首尾相接，最好是实际接触。在铁条或铁条的末端缠绕一圈绝缘导线。然后在线圈和钢条之间的铁上施加火焰或其它热源，使铁的这部分温度升高到橙红色，或大约 600 摄氏度。当达到这一条件时，如果铁很薄，它会突然失去磁性，产生的效果就好像铁从磁铁上移开或加热部分被移走一样。然而，这种状态的改变伴随着磁力线的一个转移，或者换句话说，伴随着线圈所受到的磁影响的变化，结果是线圈中产生电流。然后移开火焰或用其他方法降低铁的温度。其磁性的恢复伴随着其温度的降低，并且线圈中一个相反方向电流的发生伴随着另一种磁性状态的变化。相同的操作可以无限地重复，对线圈的影响类似于将磁化条靠近和远离铁条或铁板的端部所产生的影响。

The device forming the subject of my present invention is an improved means of obtaining this result, the features of novelty in which the invention resides being, first, the employment of an artificial cooling device, and, second, inclosing the source of heat and that portion of the magnetic circuit exposed to the heat and artificially cooling the said heated part. These improvements are applicable generally to the generators constructed on the plan above described—that is to say, I may use an artificial cooling device in conjunction with a variable or varied or uniform source of heat. I prefer, however, to employ a uniform heat.

构成本发明主题的装置是获得这一结果的改进后工具，本发明的新颖性特征在于，第一，采用人工冷却设备，第二，封闭热源并且磁路部分暴露于加热，以及人工冷却所述加热的部分。这些改进通常适用于按上述方案建造的发电机——也就是说，我可以使用一个人工冷却装置连同一个可变的或变化的或平稳的热源。然而，我更喜欢采用一个平稳的加热。

In the drawings I have illustrated a device constructed in accordance with my invention.

在附图中，我已经展示了根据我的发明来建造的装置。

Figure 1 is a central vertical longitudinal section of the complete apparatus. Fig. 2 is a cross-section of the magnetic armature-core of the generator.

图 1 是整个设备的中心垂直纵向截面图。图 2 是发电机的磁电枢铁芯的横截面图。

Let A represent a magnetized core or permanent magnet the poles of which are bridged by an armature-core composed of a casing or shell B inclosing a number of hollow iron tubes C. Around this core are wound the conductors E E', to form the coils in which the currents are developed. In the circuits of these coils are translating devices, as F F'.

让 A 代表一个被磁化的铁芯或永久磁铁，其磁极由一个电枢铁芯桥接，该电枢铁芯由一个外壳或壳体 B 组成，该外壳内有许多中空的铁管 C。导体 E E' 缠绕在铁芯上，形成产生电流的线圈。在这些线圈的电路中有转换装置，如 F F'。

D is a furnace or closed fire-box, through which the central portion of the core B extends. Above the fire is a boiler K, containing water. The flue L from the fire-box may extend up through the boiler.

D 是一个炉子或封闭的炉膛，铁芯 B 的中心部分穿过它并延伸。火的上方是一个装水的锅炉 K。来自炉膛的烟道 L 可以向上延伸穿过锅炉。

G is a water-supply pipe, and H is the steam-exhaust pipe, which communicates with all the tubes C in the armature B, so that steam escaping from the boiler will pass through said pipes.

G 是一个供水管，H 是一个蒸汽排出管，该管与电枢 B 中的所有的管 C 连通，使得从锅炉逸出的蒸汽将通过所述管。

In the steam-exhaust pipe H is a valve V, to which is connected the lever I, by the movement of which the said valve is opened or closed. In such a case as this the heat of the fire may be utilized for other purposes after as much of it as may be needed has been applied to heating the core B. There are special advantages in the employment of a cooling device, in that the metal of the core B is not so quickly oxidized. Moreover, the difference between the temperature of the applied heat and of the steam, air, or whatever gas or fluid be applied as the cooling medium, may be increased or decreased at will, whereby the rapidity of the magnetic changes or fluctuations may be regulated.

在蒸汽排出管 H 中有一个阀门 V，杠杆 I 连接到该阀门上，通过杠杆 I 的运动，所述阀门被打开或关闭。在这种情况下，在尽可能多的所需热量用于加热铁芯 B 之后，火的热量可以用

于其他目的。使用冷却装置有特殊的优点，因为铁芯 B 的金属不会很快被氧化。此外，所施加的热量与蒸汽、空气或用作冷却介质的任何气体或流体之间的温度差可以随意增加或减少，由此可以调节磁性的变化速度或波动速度。

In so far as my present invention, broadly, is concerned, the specific construction of the apparatus is largely immaterial. I do not, however, claim in this application, broadly, the application of a variable heat to vary the magnetic conditions of a field of force in which an induced conductor is contained.

就我的本发明而言，从广义上讲，该装置的具体结构在很大程度上是无关紧要的。然而，在本申请中，我并不主张广泛地应用可变热量来改变包含一个被感应导体的力场的磁条件。

What I claim is—

我主张的是—

1. In an electric generator, the combination, with a magnetized core or body and a conductor within the field of force produced thereby, of an inclosed source of heat applied to a portion of said core, and an artificial cooling device for reducing the temperature of the heated portion thereof, as set forth.

1、在一个发电机中，存在一个组合，它包括一个被磁化的铁芯或磁体以及由此产生的力场中的导体；加热所述铁芯的一部分的一个封闭热源和用于降低其加热部分的温度的人工冷却装置，如上所述。

2. The combination, with a magnetized core or body and a conductor under influence thereof, of an inclosed source of heat applied to a portion of said core, means for bringing a cooling gas or fluid in contact with the heated portion of the core, and means for controlling the admission of the same.

2、存在一个组合，它包括一个被磁化的铁芯或磁体以及受其影响的导体；加热所述铁芯的一部分的一个封闭热源；用于使冷却气体或流体与铁芯的被加热部分接触的工具；以及用于控制冷却气体或流体进入的工具。

3. The combination, with a magnetized core containing passages or channels, and coils wound thereon, of means for applying heat to a portion of the core, and a connection with a boiler for admitting steam into the channels, as set forth.

3、存在一个组合，它包括一个包含了通路或通道的被磁化的铁芯和缠绕在其上的线圈；加热铁芯的一部分的工具；以及一个与锅炉的连接，它用于允许蒸汽进入通道，如上所述。

NIKOLA TESLA.

尼古拉·特斯拉

Witnesses:

R.J. STONEY, JR.,

E.P. COFFIN.

见证人：R. J. 斯托尼、E. P. 考芬。

(No Model.)

N. TESLA.
PYROMAGNETO ELECTRIC GENERATOR.

No. 428,057.

Patented May 13, 1890.

Fig. 1

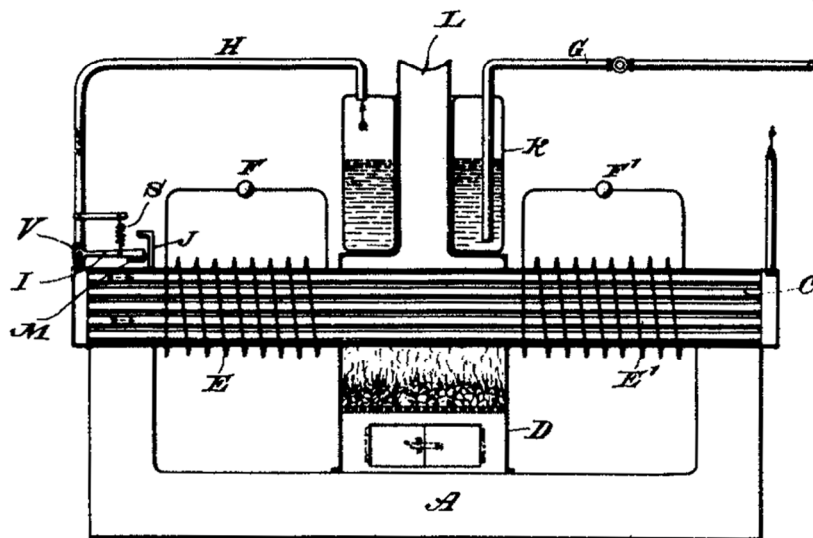
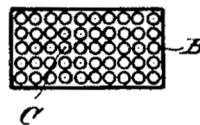


Fig. 2



Witnesses
Raphael Netter
William H. Sibley

Inventor
Nikola Tesla
By
Duncan, Curtis & Page
Attorneys

ELECTRICAL CONDENSER.

电容器

NIKOLA TESLA, OF NEW YORK, N. Y.

纽约州纽约市的尼古拉·特斯拉

SPECIFICATION forming part of Letters Patent No. 464,667, dated December 8, 1891.

Application filed August 1, 1891. Serial No. 401,356. (No model.)

该说明书形成了颁发于 1891 年 12 月 8 日编号为 464,667 的专利证书的一部分。

申请于 1891 年 8 月 1 日提交。序列号为 401,356。(没有模型)

To all whom it may concern:

致所有相关人士：

Be it known that I, NIKOLA TESLA, a citizen of the United States, residing at New York, in the county and State of New York, have invented a certain new and useful Improvement in Electrical Condensers, of which the following is a specification, reference being had to the accompanying drawings.

众所周知，我，尼古拉·特斯拉，一位美国公民，居住纽约州纽约郡纽约市，在电容器方面已经发明了某种新的和有用的改进方法，以下是该发明一个说明书，必须参考随附的参考图纸，它已形成该说明书的一部分。

The subject of my present application is a new and improved electrical condenser constructed with a view of obviating certain defects which I have observed to exist in the ordinary forms of such apparatus when employed in the system devised by me of producing light and other effects by means of currents of high frequency and high potential.

本申请的主题是一种新的和改进的电容器，它被构造的目的在于消除某些缺陷，我观察到当这种装置的普通形式被用于我设计的由高频率和高电位的电流来产生光和其他效果的系统中时，这些缺陷存在于这种装置中。

I have found that insulating material such as glass, mica, and, in general, those bodies which possess the highest specific inductive capacity are inferior as insulators in such devices when currents of the kind described are employed to those possessing high insulating power, together with a smaller specific inductive capacity, and I have also found that it is very desirable to exclude all gaseous matter from the apparatus, or any access to the same to the electrified surfaces, in order to prevent heating by molecular bombardment and the loss or injury consequent thereon. I have found that I may accomplish these results and produce highly efficient and reliable condensers by using oil as the dielectric, and in this my invention resides.

我发现，当所述类型的电流用于那些具有高绝缘能力和较小相对介电常数的物体时，绝缘材料如玻璃、云母，以及一般来说那些具有最高相对介电常数的物体作为绝缘体，在这种装置中表现较差，我还发现，将所有的气态物质从装置中排除或者排除任何进入装置并到达带电表面的入口是非常可取的，以防止由分子轰击导致加热和损耗或由此造成的伤害。我已经发现，通过使用油作为电介质，我可以实现这些结果并生产高效和可靠的电容器，这就是我的发明所在。

No special construction of the condenser is necessary to a demonstration of the invention; but the plan admits of a particular construction of condenser, in which the distance between the plates is adjustable, and of which I take advantage.

本发明的演示不需要电容器的特殊结构；但该方案承认电容器的特殊结构，其中极板之间的距离是可调的，我利用这一点。

In the accompanying drawings, Figure 1 is a section of a condenser constructed in accordance with my invention and having stationary plates, and Fig. 2 is a similar view of condenser with adjustable plates.

在附图中，图 1 是根据本发明构造的具有静态极板的电容器的截面图，图 2 是具有可调极板的电容器的类似视图。

I use any suitable box or receptacle A to contain the plates or armatures. These latter are designated by B and C and are connected, respectively, to terminals D and E, which pass out through the sides of the case. The plates ordinarily are separated by strips of porous insulating material F, which are used merely for the purpose of maintaining them in position. The space within the can is filled with oil G. Such a condenser will prove highly efficient and will not become heated or permanently injured.

我使用任何合适的盒子或容器 A 来容纳板或电容极板。后者用 B 和 C 表示，分别连接到终端 D 和 E，它们穿过外壳的侧面。这些板通常由多孔绝缘材料条 F 隔开，这些条带仅用于将它们保持在适当的位置。罐内的空间充满了油 G。这种电容器将证明是高效的，不会变热或永久损坏。

In many cases it is desirable to vary or adjust the capacity of a condenser, and this I provide for by securing the plates to adjustable supports—as, for example, to rods H—passing through stuffing-boxes K in the sides of the case A and furnished with nuts L, the ends of the rods being threaded for engagement with the nuts.

在许多情况下，需要改变或调节电容器的电容量，这通过将板固定到可调节的支撑件上来实现，例如固定到杆 H 上，杆 H 穿过壳体 A 侧面的填料盒 K 并配有螺母 L，杆的端部带有螺纹以与螺母接合。

It is well known that oils possess insulating properties, and it has been a common practice to interpose a body of oil between two conductors for purposes of insulation; but I have discovered peculiar properties in oils which render them very valuable in this particular form of device, their employment in which has never heretofore and, so far as I am aware, been regarded as necessary or even desirable.

众所周知，油具有绝缘特性，通常的做法是在两个导体之间插入一层油以达到绝缘目的；但是我发现了油的特殊性质，使它们在这种特殊形式的装置中非常有价值，它们的使用迄今为止从未被认为是必要的，甚至是可取的。

What I claim is—

我主张的是—

1. An electric condenser composed of plates or armatures immersed in oil.

1、由浸在油中的极板或电容板组成的电容器。

2. An electrical condenser composed of plates or armatures adjustable with respect to one another and immersed in oil.

2、一种电容器，由可相互调节的并浸在油中的极板或电容板组成。

NIKOLA TESLA.

尼古拉·特斯拉

Witnesses:

PARKER W. PAGE,

MARCELLA G. TRACY.

见证人:

帕克·W·佩奇、玛塞拉·G·特雷西。

(No Model.)

N. TESLA.
ELECTRICAL CONDENSER.

No. 464,667.

Patented Dec. 8, 1891.

Fig. 1

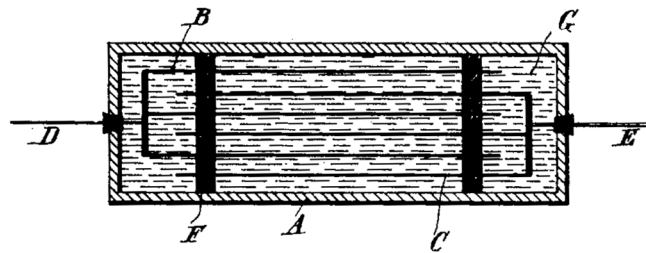
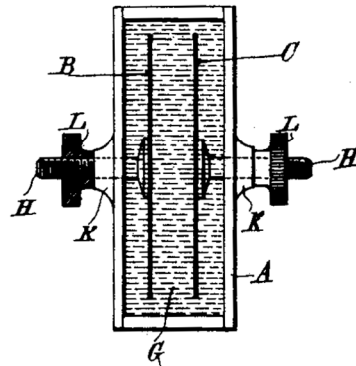


Fig. 2



Witnesses:

Raphael Neter
Frank B. Murphy,

Inventor

Nikola Tesla
by
Duncan & Page
Attorneys.

ELECTRICAL CONDENSER.

电容器

NIKOLA TESLA, OF NEW YORK, N. Y.

纽约州纽约市的尼古拉·特斯拉

SPECIFICATION forming part of Letters Patent No. 567,818, dated September 15, 1896.

Application filed June 17, 1896. Serial No. 595,928. (No model.)

该说明书形成了颁发于 1896 年 9 月 15 日编号为 567,818 的专利证书的一部分。

申请于 1896 年 6 月 17 日提交。序列号为 595,928。(没有模型)

To all whom it may concern:

致所有相关人士:

Be it known that I, NIKOLA TESLA, a citizen of the United States, residing at New York, in the county and State of New York, have invented certain new and useful Improvements in Electrical Condensers, of which the following is a specification, reference being had to the drawings accompanying and forming a part of the same.

众所周知，我，尼古拉·特斯拉，一位美国公民，居住纽约州纽约郡纽约市，在电容器方面已经发明了某种新的和有用的改进方法，以下是该发明一个说明书，必须参考随附的图纸，它已形成该说明书的一部分。

It has heretofore been announced and demonstrated by me that, under ordinary conditions, the efficiency of an electrical condenser is greatly increased by the exclusion of air or gaseous matter in general from the dielectric. In a patent granted to me December 8, 1891, No. 464,667, I have shown and described a convenient and practicable means of accomplishing this result by immersing the conducting-plates or armatures of the condenser in an insulating fluid, such as oil.

迄今为止，我已经宣布和证明，在普通条件下，通过将空气或气体物质从电介质中排除，电容器的效率会大大增加。在 1891 年 12 月 8 日授予我的第 464,667 号专利中，我已经展示并描述了一种通过将电容器的导电板或电极板浸入绝缘流体（例如油）中来实现这一结果的方便可行的方法。

My present invention, while based upon this important feature of the practically complete exclusion of air or gas from the dielectric, is an improvement on the forms of condenser heretofore described and used by me.

我的发明，虽然基于从电介质中实际上完全排除空气或气体的这一重要特征，但它是对迄今为止我所描述和使用的电容器形式的改进。

According to my present invention I employ an electrolyte, or, in general, a conducting liquid in lieu of a solid, as the material for the armatures of the condenser, under conditions more fully hereinafter described, whereby air or gas will be practically prevented from exercising upon the condenser or the more active portions of the same the detrimental effects present in such devices as heretofore made. Such condensers are especially advantageous when used with circuits of great rates of electrical vibration because of the high conducting capacity of such fluids for currents of this character. There is, however, a general advantage derived from the fact that the conducting fluids have a high specific heat, so that the temperature remains constant, a condition in many cases highly advantageous and not met with in condensers of ordinary construction.

根据我的发明，我采用了一种电解质，或者一般来说，一种代替固体的导电液体，作为电容器电极板的材料，其所处条件将在下文中更全面地描述，从而实际上防止空气或气体对电容器或其更活跃的部分产生迄今为止在这类装置中存在的有害影响。由于这种流体对这种特性的电流的高传导能力，这种电容器在与电振动速率很大的电路一起使用时特别有利。然而，由于导电流体具有一个高比热，因此温度保持恒定，这是一个普遍的优点，在许多情况下，这是在普通结构的电容器中是不具备的一个非常有利的条件。

In the accompanying drawings, annexed in illustration of the manner in which my improvement is or may be carried into practice, Figure 1 is a view, partly in vertical section, of a condenser constructed in accordance with the invention. Fig. 2 is a part vertical section of a modified form of such condenser.

在附图中，所附的是对实施或可能实施我的改进的方式的说明，图 1 是根据本发明构造的电容器的一部分垂直截面图。图 2 是这种电容器的改进形式的一部分垂直截面图。

A designates a jar or receptacle partly or wholly of conducting material and provided with a closely-fitting cap or cover B, preferably of insulating material. Within this receptacle is a smaller jar or vessel C, of insulating material, containing a conducting-electrode D, supported by the cover B, through which passes a suitable terminal E, which may be incased in an insulating-plug P. The spaces within the jars or receptacles are nearly filled with a conducting liquid F G, such as a saline solution, the two bodies of such liquid in the inner and outer receptacles constituting the condenser-armatures. Above the conducting solution in each of the receptacles is poured a layer of oil L or other insulating liquid, which serves to prevent access of air to the highly-charged armatures. The terminals for the two armatures may be provided in various ways, but in such forms of condenser as that illustrated I prefer to utilize the conducting portion of the outer receptacle as one terminal, securing a binding-post to the same, as at H, and to employ an electrode D of suitably-extended surface immersed in the liquid of the inner receptacle and in electrical connection with the binding-post E. It is desirable in some cases to modify the construction of the condenser, as when a larger capacity is required. In such instances, in order to secure the substantial benefits of the improvement above described, I construct the instrument as shown in Fig. 2. In this case I employ a jar or receptacle A which is preferably used also as one terminal and filled with a conducting liquid, as before. Into the latter extends a series of connected conductors K, enclosed and fully insulated from the liquid by a coating of such material as gutta-percha R. These conductors are electrically joined to a terminal E, which extends up through the cover B, and constitute one of the armatures of the condenser. On the surface of the electrolyte or conducting liquid is poured a quantity of oil L, for the purpose above stated. While I have illustrated the invention in its preferred form for general practical purposes, it will be understood without departure from the invention its

construction may be greatly varied and modified.

A 表示部分或全部由导电材料制成的罐或容器，并配有紧密贴合的帽或盖 B，最好由绝缘材料制成。在这个容器内的是一个较小的由绝缘材料制成的罐子或容器 C，容纳由盖子 B 支撑的导电电极 D，合适的终端 E 穿过该导电电极 D，终端 E 可以装在绝缘插头 P 中。罐子或容器内的空间几乎填满了导电液体 F G，如盐溶液，在内部和外部容器中的这种液体的两个主体构成了电容器电极板。在每个容器中的导电溶液上方，浇注一层油 L 或其他绝缘液体，用于防止空气进入高电荷电极板。用做两个电枢的终端可以以各种方式配备，但是在如图所示的电容器形式中，我更喜欢利用外部容器的导电部分作为一个终端，将接线柱固定到该终端上，如在 H 处，并且采用具有适当延伸表面的电极 D，该电极浸入容器内部的液体中并且与接线柱 E 电连接。在某些情况下，当需要更大的电容量时，需要改变电容器的结构。在这种情况下，为了确保上述改进的实质益处，我构造了如图 2 所示的仪器。在这种情况下，我采用了一个罐或容器 A，它最好也用作一个终端，并像以前一样充满导电液体。串联连接的导体 K 延伸到后者中，该导体由诸如杜仲胶的材料涂层 R 进行涂覆密封并与液体完全绝缘。这些导体被电连接到一个终端 E，该终端向上延伸穿过盖 B，并构成电容器的一个电极板。出于上述目的，在电解质或导电液体的表面上倒入一定量的油 L。尽管出于一般实用目的，我已经以其首选形式对本发明进行了说明，但是应该理解，在不背离本发明的情况下，其结构可以有很大的变化和改变。

What I claim is—

我主张的是—

1. In an electric condenser constructed or provided with means for exclusion of air and gas, and an armature composed of a conducting liquid as herein set forth.

1、在一个电容器中，该电容器被构造有或被配有用于排除空气和气体的装置，以及由本文所述的导电液体构成的电极板。

2. A condenser comprising as armatures two bodies of conducting liquid electrically insulated and contained in a receptacle from which air and gas are excluded.

2、一种电容器，包括作为电极板的两个被电绝缘的导电液主体，并被容纳在一个容器中，从该容器中空气和气体被排出。

3. A condenser comprising two bodies of conducting electrically insulated and contained in a receptacle, and a seal of insulating liquid on the surface of the liquid, as set forth.

3、一种电容器，包括两个被电绝缘且被容纳在一个容器中的导体，以及液体表面上的绝缘液体密封，如上所述。

In testimony whereof I have hereunto set my hand this 15th day of June, 1896.

本人于 1896 年 6 月 15 日在此签名为证。

NIKOLA TESLA.

尼古拉·特斯拉

Witnesses:

DRURY W. COOPER,

M. LAWSON DYER.

见证人:

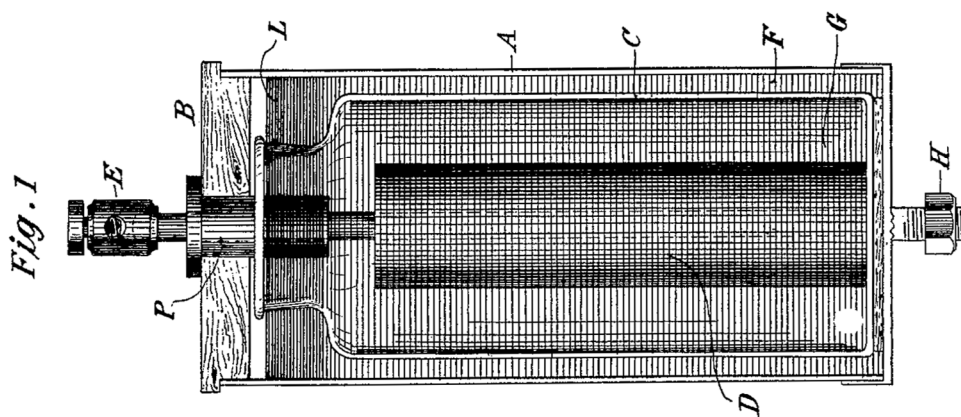
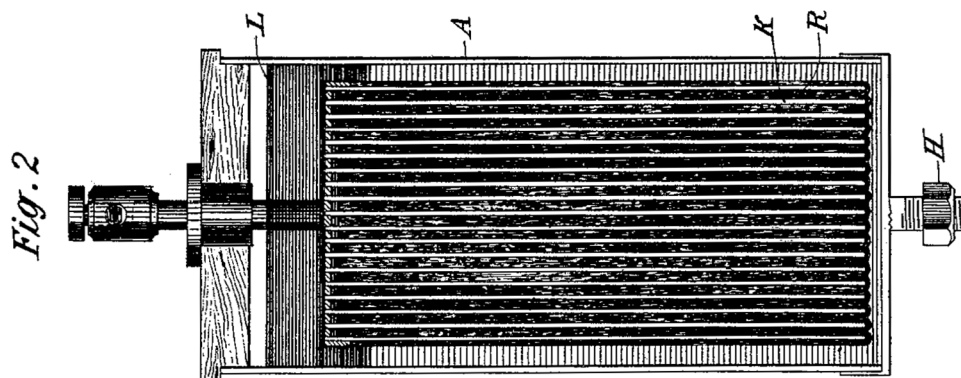
德鲁里·库珀、M.劳森·戴尔。

(No Model.)

N. TESLA.
ELECTRICAL CONDENSER.

No. 567,818.

Patented Sept. 15, 1896.



WITNESSES

Raphael Netter
Harry W. Cooper

INVENTOR

Nikola Tesla
BY
Herr. Curtis & Page
ATTORNEYS

MANUFACTURE OF ELECTRICAL CONDENSERS, COILS AND SIMILAR DEVICES

电容器、线圈及类似设备的制造

NIKOLA TESLA, OF NEW YORK, N. Y.

纽约州纽约市的尼古拉·特斯拉

SPECIFICATION forming part of Letters Patent No. 577,671, dated February 23, 1897.

Application filed November 5, 1896. Serial No. 611,126. (No model.)

该说明书形成了颁发于 1897 年 2 月 23 日编号为 577,671 的专利证书的一部分。

申请于 1896 年 11 月 5 日提交。序列号为 611,126。(没有模型)

To all whom it may concern:

致所有相关人士:

Be it known that I, NIKOLA TESLA, a citizen of the United States, residing at New York, in the county and State of New York, have invented certain new and useful Improvements in the Manufacture of Electrical Condensers, Coils, and Similar Devices, of which the following is a specification, reference being had to the drawing which accompanies and forms a part of the same.

众所周知，我，尼古拉·特斯拉，美国公民，居住纽约州纽约郡纽约市，在电容器、线圈及类似设备的制造方面已经发明了某些新的和有用的改进方法，以下是该发明一个说明书，必须参考随附的图纸，它已形成该说明书的一部分。

My invention is an improvement in the manufacture of electrical condensers, coils, and other devices of a similar character in which conductors designed to form paths for currents of high potential are brought into close proximity with each other. Among such devices are included many forms of condensers, transformers, self-induction coils, rheostats, and the like.

我的发明是对电容器、线圈和其他具有类似特性的设备的制造方面的改进，在这些装置中，设计成形成高电位电流路径的导体彼此非常靠近。在这些装置中包括许多形式的电容器、变压器、自感线圈、变阻器等。

It has heretofore been shown by me that the efficiency and practicability of such devices are very greatly enhanced by the exclusion of air or gas from the dielectric separating the conductors or remote portions of the same conductor; and the object of my present improvement is to secure such exclusion of air in as perfect a manner as possible in a convenient and practicable way. To this end I place the condenser or other device to be treated in a receptacle from which the air may be more or less perfectly exhausted, and while in vacuum I introduce an insulating substance, which liquefies when subjected to heat, such

as paraffin, which surrounds the said device and finds its way into its interstices.

迄今为止，我已经表明，通过将空气或气体从用来分隔导体或同一导体的不同远端部分的电介质中排除空气或气体，这种装置的效率和实用性大大提高；我目前改进的目的是以方便可行的方式尽可能完美地排除空气。为此，我把电容器或其他要被处理的设备放置在一个容器中，空气可能或多或少从该容器中完全排出，而在真空中我引入一种绝缘物质，当受热时会液化，如石蜡，围绕着所说的设备，并找到它的间隙。

When the device has become thoroughly saturated with the insulating material, it is allowed to cool off usually until the material begins to solidify. Air is then admitted under pressure to the receptacle containing the device and the pressure maintained until the whole mass of insulating material has solidified. By this treatment the presence of air or vacuous spaces in the dielectric, which are otherwise liable to form by the contraction of the insulating material when cooling, is prevented.

当设备被绝缘材料完全浸透时，通常允许冷却，直到材料开始凝固。然后，空气在压力下进入容纳了该装置的容器，并保持该空气压力，直到整个绝缘材料凝固。通过这种处理，防止了电介质中空气或真空空间的存在，否则它们容易由于绝缘材料冷却时的收缩而形成。

Any plan may be followed or apparatus used for securing the two conditions necessary to the attainment of the desired result; that is to say, applying the fluid insulating material in vacuum and subsequently subjecting it to or solidifying it under pressure. The degree of exhaustion or of pressure may vary, very good results being secured by a vacuum of about twenty-nine inches and a pressure of about one hundred pounds. It may be stated, however, that when hydraulic pressure is applied very much higher pressures are readily secured and are of advantage.

可以遵循任何方案或使用任何设备来确保达到预期结果所必需的两个条件；也就是说，在真空中施加流体绝缘材料，随后使其经受压力或在压力下固化。排气程度或压力可能会有所不同，非常好的结果是由大约 29 英寸的真空和大约 100 磅的压力来确保。然而，可以说，当施加液压时，更高的压力很容易得到保证并且是有利的。

In order to facilitate the carrying out of the process, I have devised a simple and useful apparatus, which is illustrated partly in section in the accompanying drawing. As the parts of said apparatus are all of well-known construction, the apparatus as a whole will be fully understood without a full description of its details.

为了便于实施该方法，我已经设计了一种简单且有用的装置，已经部分地在附图中以截面图展示。由于所述设备的部件都是众所周知的结构，因此无需对其细节进行全面描述，就能完全理解该设备的整体。

A is a tank or receptacle that may be closed air-tight. Within this tank is a steam-coil C, surrounding a vessel B, preferably with slightly-sloping sides and provided with a tube or pipe D, opening into it near its base.

A 是可以密封的水箱或容器。在该水箱内是一根蒸汽盘管 C，它围绕着容器 B，容器 B 最好具有稍微倾斜的侧面，并配有管或导管 D，在其底部附近通向容器中。

The condenser or other device to be treated is placed in the vessel B, and around the receptacle is packed a suitable insulating material in quantity sufficient when liquefied by heat to flow through the pipe D into the vessel B and fill the space in the latter up to the top of the condenser or other device placed therein.

将待处理的电容器或其它装置放置在容器 B 中，并且在容器周围填充适当的绝缘材料，材料的量足以在受热液化时通过管道 D 流入容器 B 中，并且填充容器 B 中的空间，直到放置在其中电容器的顶部或其它装置的顶部。

It is desirable to run into the pipe D enough melted material to fill it before using the apparatus and to make the pipe of a poor heat-conducting material, so that a little time will elapse after the heat is applied to melt the material in the tank A before the flow through the pipe begins.

在使用设备之前，最好在管道 D 中注入足够的熔化材料以填充它，并且用导热性差的材料制造管道，以便在加热熔化箱体 A 中的材料之后，在流动通过管道之前，会经过一段时间。

When the apparatus has been thus prepared, the air from the interior of the tank A is withdrawn as completely as practicable by an air-pump E and steam is passed through the coil C. In order to prevent access of any of the volatile constituents of the insulating material to the pump, a condenser F, with a cooling-coil G, is interposed in the piping between the tank and pump. After a partial vacuum has been secured in the tank A and the liquefied insulating material has been run into the vessel B the pump may be stopped and the tank connected with a receiver H, from which the air has been exhausted, and the apparatus allowed to stand until all the interstices of the condenser have been permeated with the insulating material. The steam is then shut off and cold water passed through the coil C. The connections with the pump are then reversed and air is forced into the tank and receiver H and the further cooling and solidification of the insulating material carried on under a pressure considerably greater than that of the atmosphere. After the insulating material has cooled and solidified the condenser or other device, with the adhering mass of insulating material, is removed from the receptacle and the superfluous insulating material taken off.

当装置已经如此准备好时，通过气泵 E 尽可能完全地抽出箱体 A 内部的空气，并且蒸汽通过盘管 C。为了防止绝缘材料的任何挥发性成分接近泵，具有冷却盘管 G 的冷凝器 F 被置于箱体和泵之间的管道中。在箱体 A 中已确保部分真空并且被液化的绝缘材料已经流入容器 B 中之后，可以停止泵，并且箱体与接受罐 H 连接，空气已经从接受罐 H 中排出，并且允许设备站立，直到电容器的所有空隙都被绝缘材料渗透。然后关闭蒸汽，冷水通过盘管 C。然后，与泵的连接被反转，空气被压入箱体和接受罐 H，绝缘材料的进一步冷却和固化在比大气压力大得多的压力下进行。在绝缘材料冷却并固化后，带有绝缘材料粘附块的电容器或其它装置从容器中取出，并去掉多余的绝缘材料。

I have found that condensers, transformers, and similar apparatus treated by this process are of very superior quality and especially suited for circuits which convey currents of high frequency and potential.

我发现用这种方法处理过的电容器、变压器和类似的设备质量非常好，特别适合于输送高频和高电位电流的电路。

I am aware that conductors covered with a more or less porous material have been treated by placing them in a closed receptacle, exhausting the air from the receptacle, then introducing a fluid insulating compound and subjecting the same to pressure, for the purpose of more perfectly incorporating the insulating compound with the surrounding coating or covering of the conductors and causing such compound to enter the interstices in said covering, and I apply this principle of exhausting the air and introducing the fluid insulating compound under pressure in carrying out my improvement. My process, however, differs from the foregoing mainly in this, that I seek not only to fill the pores of any porous material that may be interposed between the conductors of such a device as a condenser or coil, but to fill up all the spaces in the dielectric, whereby air or vacuous spaces, the presence of which in the dielectric is so deleterious to the device, may be effectually prevented. To this end I permit the insulating compound after its incorporation with the device, under exhaustion and pressure, to cool and solidify, so that not only is the air replaced by a solid insulating compound, but the formation of vacuous spaces by the contraction of the mass on cooling prevented.

我知道，为了更好地将绝缘化合物与导体的周围涂层或覆盖物结合，并使这种化合物进入所述覆盖物中的空隙，已经通过将导体放入封闭的容器中，从容器中排出空气，然后引入流体绝缘化合物并对其施加压力，对覆盖具有或多或少多孔材料的导体进行了处理，并且我在进行我的改进时应用了这种排出空气并在压力下引入流体绝缘化合物的原理。然而，我的方法与前述方法的不同之处主要在于，我不仅寻求填充任何可能介入电容器或线圈等器件的导体之间的多孔材料的孔隙，而且寻求填充电介质中的所有空间，从而可以有效地防止电介质中存在的对器件有害的空气或真空空间。为此，我允许绝缘化合物在与设备结合后，在排气和压力下进行冷却和固化，这样不仅空气被固体绝缘化合物取代，而且通过团块的冷却收缩所形成的真空空间被阻止。

What I claim is—

我主张的是—

The improvement in the manufacture of electrical devices such as condensers, which consists in enclosing the device in an air-tight receptacle, exhausting the air from the receptacle, introducing into a vessel containing the device an insulating material rendered fluid by heat, and then when said material has permeated the interstices of the said device, subjecting the whole to pressure, and maintaining such pressure until the material has cooled and solidified, as set forth.

对诸如电容器的电气设备的制造的改进，包括将该设备封装在气密容器中，从容器中排出空气，将通过加热而变成流体的绝缘材料引入容纳该设备的容器中，然后当所述材料已经渗透到所述设备的间隙中时，对整个设备施加压力，并维持该压力，直到该材料冷却并固化，如前所述。

NIKOLA TESLA.

尼古拉·特斯拉

Witnesses:

M. LAWSON DYER,

PARKER W. PAGE.

见证人：M.劳森·戴尔、帕克·W·佩奇。

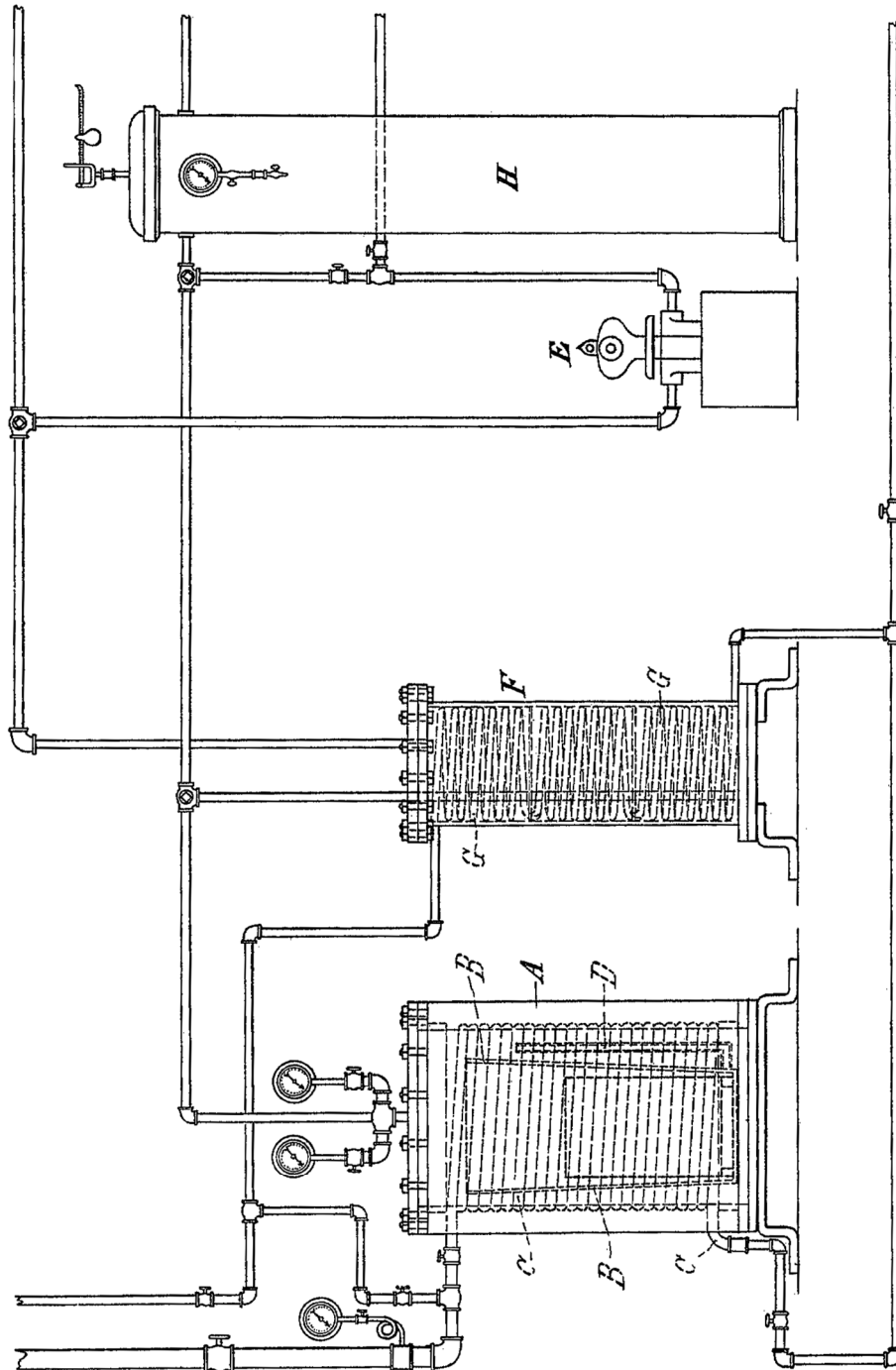
(No Model.)

N. TESLA.

MANUFACTURE OF ELECTRICAL CONDENSERS, COILS, &c.

No. 577,671.

Patented Feb. 23, 1897.



WITNESSES

Edwin B. Hopkinson,
Benjamin Miller,

INVENTOR

Nikola Tesla

BY

Ken. Curtis & Page

ATTORNEYS.

ELECTRICAL METER.

电表

NIKOLA TESLA, OF NEW YORK, N. Y.

纽约州纽约市的尼古拉·特斯拉

SPECIFICATION forming part of Letters Patent No. 455,068, dated June 30, 1891.

Application filed January 27, 1891. Serial No. 386,666. (No model.)

该说明书形成了颁发于 1891 年 6 月 30 日编号为 455,068 的专利证书的一部分。

申请于 1891 年 1 月 27 日提交。序列号为 386,666。(没有模型)

To all whom it may concern:

致所有相关人士:

Be it known that I, NIKOLA TESLA, a subject of the Emperor of Austria, from Smiljan, Lika, border country of Austria-Hungary, and a resident of New York, in the county and State of New York, have invented certain new and useful Improvements in Electrical Meters, of which the following is a specification, reference being had to the drawings accompanying and forming a part of the same.

众所周知，我、尼古拉·特斯拉、一位奥匈帝国的臣民，来自奥匈帝国边境地区的利卡县的史密里安村，现在居住在纽约州纽约郡纽约市，在电表方面已经发明了某些新的和有用的改进，以下是该发明一个说明书，必须参考随附的参考图纸，它已形成该说明书的一部分。

My invention pertains to methods of and apparatus for estimating the electrical energy that has been expended in an electrical circuit or any given portion of the same.

我的发明涉及用于估计已经在电路中或电路的任何给定部分中消耗的电能的装置的（和）方法。

The principle of the invention is embodied in any form of apparatus in which a conductor immersed in an electrolytic solution is so arranged that metal may be deposited upon it or taken away from it in such manner that its electrical resistance is varied in a definite proportion to the strength of the current the energy of which is to be computed, whereby such variation in resistance may serve as a measure of the energy or may be utilized in various well-understood ways to bring into action suitable automatic registering mechanism when the resistance exceeds or falls below predetermined limits.

本发明的原理体现在任何形式的装置中，浸入电解溶液中的导体被布置成使得金属可以沉积在该导体上或从该导体取走，使得该导体的电阻与电流强度成确定的比例变化，该电流强度将被计算出来，由此电阻的这种变化可以用作能量的量度，或者可以用各种很好理解的方式被利用，以在电阻超过或低于预定极限时使合适的自动记录机械装置起作用。

In carrying out my invention I prefer to employ an electrolytic cell, through which extend two conductors parallel and in close proximity to each other. I connect these conductors in series through a resistance, but in such manner that there is an equal difference of potential between them throughout their entire extent. The free ends or terminals of the conductors are connected either in series in the circuit supplying the current to the lamps or other devices or in parallel to a resistance in the said circuit and in series with the translating devices. Under such circumstances a current passing through the conductors establishes a difference of potential between them which is proportional to the strength of the current, in consequence of which there is a leakage of current from one conductor to the other across the solution. The strength of this leakage current is proportional to the difference of potential, and, therefore, in proportion to the strength of the current passing through the conductors. Moreover, as there is a constant difference of potential between the two conductors throughout the entire extent that is exposed to the solution, the current density through such solution is the same at all corresponding points, and hence the deposit is uniform along the whole of one of the conductors, while the metal is taken away uniformly from the other. The resistance of one conductor is by this means diminished, while that of the other is increased both in proportion to the strength of the current passing through the conductors. From such variation in the resistance of either or both of the conductors forming the positive and negative electrodes of the cell the current energy expended may be readily computed.

在实施我的发明中，我更喜欢使用电解池，延伸两个平行的导体通过它，彼此非常接近。我用一个电阻将这些导体串联起来，但是要使它们之间的电位差在整个长度范围内相等。导体的自由端或终端或者被串联在向灯或其他设备提供电流的电路中，或者并联到所述电路中的一个电阻并与转换设备串联。在这种情况下，流过导体的一个电流在导体之间产生电位差，该电位差与电流的强度成正比，结果，电流经过溶液从一个导体泄漏到另一个导体。这种泄漏电流的强度与电位差成正比，因此也与通过导体的电流强度成正比。此外，由于在暴露于溶液的整个长度范围内的两个导体之间存在恒定的电位差，所以流经这种溶液的电流，其密度在所有相应的点都是相同的，因此，沿着其中一个导体的整个部分的沉积物是均匀的，而金属也从另一个导体被均匀地带走。通过这种方法，一个导体的电阻减小了，而另一个导体的电阻增加了，两个电阻的变化都与通过导体的电流强度成正比。从形成电池的正电极和负电极的导体之一或两者电阻的这种变化，可以容易地计算出消耗的电流能量。

Other modified arrangements of the conductors are contemplated, as will be understood from the following description and reference to the drawings.

从下面的描述和对附图的参考中可以理解的，可以设想导体的其他修改的布置。

The figures are diagrams showing the meter in operative relations to a working-circuit and under slightly-modified arrangements.

这些图是展示了与工作电路的操作关系以及在稍微修改的布置下的仪表的示意图。

In Fig. 1, G designates a suitable direct-current generator. L L are the conductors of the circuit extending therefrom and including and supplying lamps or other translating devices T. A is a tube, preferably of glass, the ends of which are sealed, as by means of insulating plugs or caps B B. C C' are two conductors extending through the tube A, their ends passing out through the plugs B to terminals thereon. These conductors may be corrugated or formed in other proper ways to offer the desired electrical resistance.

R is a resistance connected in series with the two conductors C C', which by their free terminals are connected up in the circuit of one of the conductors L.

在图 1 中, G 表示合适的一个直流发电机。LL 是从那里延伸出的电路导体, 包含了灯或其他转换装置 T, 并为这些装置供电。A 是一个管子, 最好是玻璃的, 其端部用绝缘塞或绝缘帽 BB 密封。CC' 是两个穿过管子 A 的导体, 它们的端部穿过塞子 B 到达其上的终端。这些导体可以是波纹状的或以其他适当的方式制成, 以提供所需的电阻。R 是与两个导体 CC' 串联的电阻, 这两个导体通过它们的游离端连接到导体 LL 其中之一所在的电路中。

The method of using this device and computing by means thereof the energy of the current will be readily understood. First, the resistances of the two conductors C C', respectively, are accurately measured and noted. Then a known current is passed through the instrument for a given time, and by a second measurement the increase and diminution of the resistances of the two conductors respectively taken. From these data the constant is obtained—that is to say, for example, the increase of resistance of one conductor or the diminution of the resistance of the other per lamp-hour. These two measurements evidently serve as a check, since the gain of one conductor should equal the loss of the other. A further check is afforded by measuring both wires in series with the resistance, in which case the resistance of the whole should remain constant.

使用该装置并通过其计算电流能量的方法将很容易理解。首先, 分别精确测量并记录两个导体 CC' 的电阻。然后, 在给定的时间内, 一个已知的电流流经该仪器, 然后经过第二次测量, 分别获得两个导体电阻的增加和减少。从这些数据获得常数——也就是说, 例如, 一盏灯在每小时内让一个导体的电阻增加量或另一个导体的电阻减少量。这两个测量显然是作为一个检查, 因为一个导体获得的应该等于另一个导体失去的。通过测量与电阻串联的两根导线, 可以进行进一步的检查, 在这种情况下, 整个电阻应该保持不变。

In Fig. 2 the conductors C C' are connected in parallel, the current divided at X passing in one branch first through a resistance R' and then through conductor C, while in the other branch it passes first through conductor C', and then through resistance R". The resistances R' R" are equal, as also are the resistances of the conductors C C'. It is, moreover, preferable that the respective resistances of the conductors C C' should be a known and convenient fraction of the coils or resistances R' R". It will be observed that in the arrangement shown in Fig. 2 there is a constant potential difference between the two conductors C C' throughout their entire length.

在图 2 中, 导体 CC' 并联连接, 在 X 处分流的电流在一个支路中首先通过电阻 R', 然后通过导体 C, 而在另一个支路中, 电流首先通过导体 C', 然后通过电阻 R"。电阻 R' R" 相等, 导体 CC' 的电阻也相等。此外, 导体 CC' 各自的电阻应该是线圈或电阻 R' R" 的一个已知且方便的分数的。可以观察到, 在图 2 所示的布置中, 在两个导体 CC' 的整个长度上存在恒定的电势差。

It will be seen that in both cases illustrated the proportionality of the increase or decrease of resistance to the current strength will always be preserved, for what one conductor gains the other loses, and the resistances of the conductors C C' being small as compared with the resistances in series with them. It will be understood that after each measurement or registration of a given variation of resistance in one or both conductors the direction of the current should be changed or the instrument reversed, so that

the deposit will be taken from the conductor which has gained and added to that which has lost. This principle is capable of many modifications. For instance, since there is a section of the circuit—to wit, the conductor C or C'—that varies in resistance in proportion to the current strength, such variation may be utilized, as is done in many analogous cases, to effect the operation of various automatic devices, such as registers. I prefer, however, for sake of simplicity to compute the energy by measurements of resistance.

可以看出,在所示的两种情况下,电阻的增加或减少与电流强度的比例将总是保持不变,因为一个导体获得的是另一个导体失去的,并且导体 C C' 的电阻与和它们串联的电阻相比是小的。应当理解,在每次测量或记录一个或两个导体中的电阻的给定变化之后,应当改变电流的方向或反转仪器,以便从得到增益的导体中获得沉积物,并添加到已经产生消耗的导体中。这个原理可以做许多修改。例如,由于电路中有一部分——即导体 C 或 C'——其电阻随电流强度成比例地变化,这种变化可以用来实现各种自动装置的操作,如自动记录器。然而,为了简单起见,我更喜欢通过测量电阻来计算能量。

The chief advantages of this invention are, first, that it is possible to read off directly the amount of the energy expended by means of a properly-constructed ohm-meter and without resorting to weighing the deposit; second, it is not necessary to employ shunts, for the whole of the current to be measured may be passed through the instrument; third, the accuracy of the instrument and correctness of the indications are but slightly affected by changes in temperature. In addition to these advantages the invention possesses the merit of economy in the waste of energy and simplicity, compactness, and cheapness in construction.

本发明的主要优点是,第一,可以通过适当构造的欧姆表直接读出消耗的能量,而不需要对沉积物称重;第二,没有必要使用分流器,因为整个被测量的电流都可以通过该仪器;第三,仪器的精确度和指示的正确性受温度变化的影响很小。除了这些优点之外,本发明还具有节约能源和结构简单、紧凑和廉价的优点。

What I claim is—

我主张的是—

1. The method of computing the amount of electrical energy expended in a given time in an electric circuit, which consists in maintaining by the current a potential difference between two conductors in an electrolytic solution uniform throughout the whole extent of such conductors exposed to the solution and measuring the variation of the resistance in one or both of said conductors due to the gain or loss of metal by electro-deposition, as set forth.

1、一种计算电路在一个给定时间内消耗的电能的方法,该方法包括通过电流来使得电解液中两个导体之间的电势差在暴露于溶液中的导体的整个长度范围内保持一致,并测量一个或两个所述导体中的电阻变化,该电阻变化是由于通过电沉积来获得或损失金属而引起的,如前所述。

2. The combination, with an electric circuit, of a meter composed of an electrolytic cell and two conductors passing through the same, the said conductors being in or connected with the main circuit

and so that a potential difference uniform throughout the whole extent exposed to the solution will be maintained between them, as set forth.

2、由一个电解池和穿过该电解池的两个导体组成的计量表与电路的组合，所述导体在主电路中或与主电路连接，从而在它们之间保持暴露于溶液的整个长度范围内均匀的电势差，如上所述。

3. The combination, with an electric circuit containing translating devices, of a meter composed of an electrolytic cell and two conductors passing through the same and connected in series with the translating devices, and one or more resistances connected therewith for establishing a potential difference between the two conductors through the solution of the cell, as set forth.

3、存在一个组合，它包括：包含转换装置的一个电路；一个计量表，由一个电解池和两个穿过电解池并与转换装置串联的导体所组成；以及一个或多个与导体连接的电阻，用于在穿过电解池溶液的两个导体之间建立电势差，如上所述。

4. An electrical meter consisting of an electrolytic cell, two parallel conductors extending through the same, the said conductors being connected together in series through a resistance and having terminals at their free ends for connection with a circuit, these parts being combined in the manner substantially as set forth.

4、一种电表，包括一个电解池；两个穿过电解池的平行导体，所述导体通过一个电阻串联在一起，并且在它们的游离端具有用于连接电路的终端，这些部件以基本上所述的方式进行组合。

5. An electric meter consisting of a tubular cell containing an electrolytic solution and closed at the ends, two parallel conductors extending through the cell, a resistance-connection between the end of one conductor and the opposite end of the other, and terminals for the remaining ends of the respective conductors, these parts being combined as set forth.

5、一种电表，包括一个装有电解液的管状电解池，两端封闭；两个平行的导体穿过电池，一个导体的一端和另一个导体的相对一端之间有一个电阻连接，各个导体的另外一端有接线终端，这些部件按上述方式组合在一起。

NIKOLA TESLA.
尼古拉·特斯拉

Witnesses:

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(No Model.)

N. TESLA.
ELECTRICAL METER.

No. 455,068.

Patented June 30, 1891.

Fig. 1

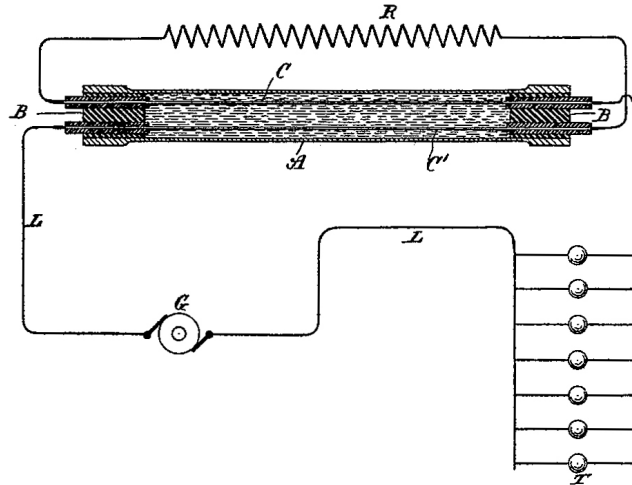
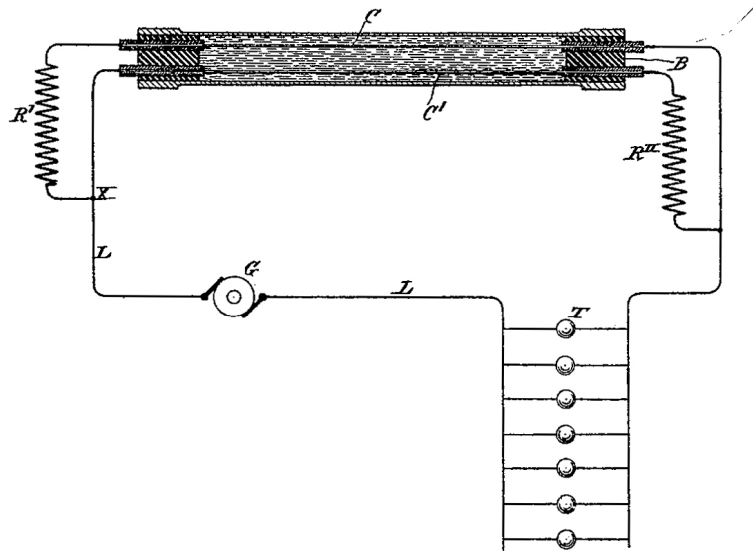


Fig. 2



Witnesses:

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ELECTRICAL METER.

电表

NIKOLA TESLA, OF NEW YORK, N. Y.

纽约州纽约市的尼古拉·特斯拉

SPECIFICATION forming part of Letters Patent No. 514,973, dated February 20, 1894.

Application filed December 15, 1893. Serial No. 493,739. (No model.)

该说明书形成了颁发于 1894 年 2 月 20 日编号为 514,973 的专利证书的一部分。

申请于 1891 年 1 月 27 日提交。序列号为 386,666。(没有模型)

To all whom it may concern:

致所有相关人士:

Be it known that I, NIKOLA TESLA, a citizen of the United States, residing at New York, in the county and State of New York, have invented certain new and useful Improvements in Electrical Meters, of which the following is a specification, reference being had to the drawings accompanying and forming a part of the same.

众所周知，我、尼古拉·特斯拉、一位美国公民，现在居住在纽约州纽约郡纽约市，在电表方面已经发明了某些新的和有用的改进，以下是该发明一个说明书，必须参考随附的图纸，它已形成该说明书的一部分。

The subject of this invention is a novel method of and apparatus for computing the energy that has been expended in a given time in a circuit, and is more particularly designed for measuring the expended energy of alternating currents and those of varying strength.

本发明的主题是一种用于计算电路中在给定时间内消耗的能量新颖的方法和装置，更具体地说，是为测量交流电的消耗能量和交流电的强度变化而设计的。

The invention is based on the fact that when a high tension discharge is made to pass from a conductor through a rarefied gas, minute particles are thrown off from the conductor and are embodied in any apparatus in which the proper conditions for the above results are present, and in which the amount of the particles thrown off from the conductor or conductors as a result of such action is in proportion to the strength of the current, the energy of which is to be computed, and can be measured from time to time. As the most convenient means of utilizing this principle in carrying out my invention, I have devised an instrument of the following character: In a tube or other receiver, preferably of glass, are placed two conductors, parallel to each other. The most convenient conductors for this purpose are composed of thin sticks or filaments of homogeneous carbon, to the ends of which platinum wires are attached, which latter are sealed in the glass, and, inside the tube protected by a coating of some insulating material, while their ends outside of the tube are connected to or formed as suitable terminals.

The glass tube is provided with a small tube through which it is exhausted to the proper degree and which is sealed off after exhaustion in the usual manner. If the two conductors or carbons be connected to the two parts of a circuit over which flows an alternating current of high tension, a discharge takes place from one carbon to the other alternately, that causes infinitesimal particles to be thrown off from each, which appreciably increases their electrical resistance. This variation may be used as a measure of the energy of a current in a working circuit, as I shall now explain more in detail and by referring to the drawings hereto annexed, and in which—

本发明基于这样的事实，即当一个高压放电从一个导体通过稀薄气体时，微小粒子从导体中脱落，并存在于任何具有产生上述结果的适当条件的仪器中，并且作为这种动作的结果，从导体中脱落的微粒的量与电流的强度成比例，电流的能量将被计算，并且可以时不时地被测量。作为在实施我的发明中利用这一原理的最方便的方法，我设计了一个具有如下特征的仪器：在一个管或其他接收器中，最好是玻璃，放置两个导体，彼此平行。用于此目的的最方便的导体由同类型碳制作的细棒或细丝，铂丝连接到其端部，铂丝被密封在玻璃中，并且在管内由某种绝缘材料的涂层保护，而它们在管外的终端连接到合适的终端。或形成合适的终端。玻璃管配有一个小管，通过该小管将气体排除到适当的程度，并在排除后以通常的方式密封。如果两个导体或碳被连接到电路的两个部分，高压交流电流过电路的两个部分，放电从一个碳到另一个碳交替发生，这导致无限小的微粒脱落，这明显增加了它们的电阻。这种变化可以用作工作电路中电流能量的量度，我现在将参考附图更详细地解释，其中—

Figure 1 illustrates the instrument above described and, diagrammatically, the manner of using the same. Fig. 2 is a cross section on an enlarged scale of one of the carbon conductors.

图 1 展示了上述仪器，并示意性地展示了该仪器的使用方式。图 2 是一个碳导体的放大截面图。

One terminal of each of the carbon conductors A, B, sealed as above described in the tube or receiver C, is connected to a terminal of the secondary D of a high tension induction coil, preferably constructed without iron. The carbons are supported by the metallic conductors H, preferably of platinum in whole or in part, and having inside the receiver a coating of insulating material L. The primary E of the induction coil is connected in series with incandescent lamps or other non-inductive translating devices F, supplied with alternating currents from an suitable generator G. Under these conditions, since the difference of potential at the terminals of the secondary of the induction coil is proportionate to the primary current, it is, therefore, proportionate to the number of lamps or other devices F.

如上所述的被密封在管或接收器 C 中的碳导体 A、B 中的每一个导体的一个终端被连接到一个高压感应线圈的次级 D 的一个终端，该高压感应线圈最好地没有铁芯。碳由金属导体 H 支撑，导体 H 最好全部或部分由铂制成，并且在接收器内部具有绝缘材料涂层 L。感应线圈的初级 E 与白炽灯或其它非感应转换装置 F 串联连接，由一个合适的发电机 G 提供交流电。在这种情况下，由于感应线圈的次级的两终端的电位差与初级电流成正比，因此与灯或其它设备的数量成正比。

The action of the discharge in the tube C from one conductor to the other produces a uniform throwing off of the infinitesimal particles of carbon along the entire length of the conductors, as the difference of potential between the two is practically equal at all points, and the increase in resistance will, therefore,

be uniform. The amount, however, of the particles thus thrown off in a given time is proportionate to the difference of potential between the two conductors, and hence the increase in the resistance of the conductors is in a definite proportion to the number of lamp hours. Thus, the energy may be computed from the variation in the resistance of the conductors in the following manner: The resistances of the conductors are accurately measured in any of the usual ways. Then a known current is caused to pass for a given time through the primary of the induction coil and a given number of lamps. The resistances of the conductors are then taken again and the increase gives the constant which permits of the calculation of the energy consumed from the variation in the resistance of one conductor.

在管 C 中从一个导体到另一个导体的放电作用产生了沿着导体的整个长度的碳的无限小微粒的均匀脱落, 因为两者之间的电位差实际上在所有点上都是相等的, 因此电阻的增加将是均匀的。然而, 给定的时间内脱落的粒子的数量与两个导体之间的电位差成正比, 因此导体电阻的增加与灯小时数成一个明确的比例。因此, 可以通过以下方式根据导体电阻的变化来计算能量: 导体的电阻可以用任何一种常用的方法精确地测量出来。然后, 在给定的时间内, 使已知的电流流过感应线圈的初级线圈和给定数量的灯。然后再次测量导体的电阻, 其增加量给出一个常数, 该常数允许计算一个导体的电阻变化所消耗的能量。

To simplify the calculation, the carbon conductors may be made rectangular in cross-section, see Fig. 2, which is an enlarged cross-section of one of the carbons, coated with an insulating substance M, so as to expose only one side from which the material is thrown off. In such case the variation of resistance may be simply multiplied by the constant to determine the energy. But it is an easy matter to determine by a simple calculation the amount of energy expended in any case, provided the dimensions of the conductor are known. The former plan is preferable, however, as by it the energy may be directly read off by using a properly graduated ohm meter.

为了简化计算, 碳导体的横截面可以做成矩形, 见图 2, 图 2 是涂有绝缘物质 M 的一个碳的放大横截面, 以便只暴露材料会脱落的一侧。在这种情况下, 电阻的变化可以简单地乘以常数来确定能量。但是, 只要知道导体的尺寸, 通过简单的计算就可以很容易地确定在任何情况下所消耗的能量。然而, 前一种方案是更可取的, 因为通过这种方案, 可以使用适当刻度的欧姆表直接读出能量。

If inductive resistance be used in place of the lamps F, it will be understood that the conditions for ascertaining the energy expended must be varied accordingly and in well understood ways, which require no special description herein.

如果使用电感电阻来代替灯 F, 可以理解的是, 用于确定所消耗能量的条件必须相应地以众所周知的方式改变, 这在这里不需要特别的描述。

I do not limit myself to the specific construction of the instrument herein shown, for the same may be varied in many well understood ways. For example, only one of the two conductors need be inside the tube, it being only necessary that they be placed in such relations that the high tension discharge shall take place between them through the rarefied gas.

我并不将自己局限于这里所展示的仪器的具体结构, 因为同样的结构可以以许多众所周知的方式变化。例如, 两个导体中只有一个需要在管内, 只需要它们以这样的关系放置, 使得高

压放电将通过稀薄气体在它们之间发生。

The above described plan I regard as the most convenient for ascertaining the amount of the particles thrown off from the conductors, but other means for this purpose may be resorted to.

我认为上述方案对于确定从导体上脱落的微粒数量是最方便的,但其他手段也可以达到这个目的。

What I claim as my invention is—

我主张我的发明是—

1. The method, herein described, of measuring the amount of electrical energy expended in a given time in an electric circuit of alternating currents, which consists in maintaining by such currents a high tension discharge through a rarefied gas between two conductors, and computing from the amount of the particles thrown off from said conductors or one of the same by the action of the discharge of the energy expended.

1、在此描述的测量在给定时间内在交流电路中消耗的电能的方法,该方法包括通过这样的电流来维持通过两个导体之间的稀薄气体的高压放电,以及利用放电所消耗的能量作用,从所述导体或其中一个导体脱落的粒子的量进行计算。

2. The combination with a circuit of alternating currents, of a meter composed of two conductors connected respectively with the circuit and separated by a rarefied gas substantially as set forth.

2、由两个导体组成的仪表与电路或交流电的组合,这两个导体分别与电路相连,并由稀薄气体隔开,基本上如前所述。

3. The combination with a working circuit of alternating currents, translating devices substantially as described connected therewith, a primary coil in series with the translating device and a high tension secondary therefore, of a meter composed of an exhausted receiver having two conductors sealed therein, one terminal of each conductor being connected to a terminal of the secondary, as set forth.

3、存在一个组合,包括:交流电流的工作电路;基本上如所述与该电路连接的转换装置;与转换装置串联的初级线圈及其高压次级线圈;由一个排除了空气的接收器构成的仪表,该接收器有两个导体,每个导体的一个终端连接到次级线圈的一个终端,如上所述。

4. A meter for electric currents, consisting in the combination with an exhausted receiver, of two conductors contained therein and connected with wires sealed into the walls of said receiver, the said meter having two line or circuit terminals, one connected with each conductor, therein, as set forth.

4、一种用于电流的仪表,包括:一个排除了空气的接收器;两个包含在其中的导体,并与密封在所述接收器的壁中的导线连接,所述仪表具有两个线路或两个电路终端,每个终端都连接着两个导体,如前所述。

5. A meter for electric currents, consisting in the combination with an exhausted receiver of two rectangular carbon conductors mounted therein and coated with an insulating material on three sides, as and for the purpose set forth.

5、一种电流表，包括安装在电表中的两个矩形碳导体的排除空气的接收器，三面涂有绝缘材料，用于所述目的。

6. A meter for electric currents, consisting in the combination with an exhausted receiver, of two carbon conductors presenting surfaces between which a discharge is adapted to take place, and metallic conductors sealed in the walls of the receiver and supporting said carbons, the metallic conductors inside the receiver being coated with an insulating material, as set forth.

6、一种电流表，包括：排除了空气的接收器；两个碳导体，它们具有适于在它们之间发生放电的表面；被密封在接收器壁中并支撑所述碳的金属导体；接收器内部的金属导体涂覆有绝缘材料，如前所述。

NIKOLA TESLA.

尼古拉·特斯拉

Witnesses:

JAMES N. CATLOW,

PARKER W. PAGE.

见证人:

詹姆斯·N·卡特洛、帕克·W·佩奇。

(No Model.)

N. TESLA.
ELECTRICAL METER.

No. 514,973.

Patented Feb. 20, 1894.

Fig. 1

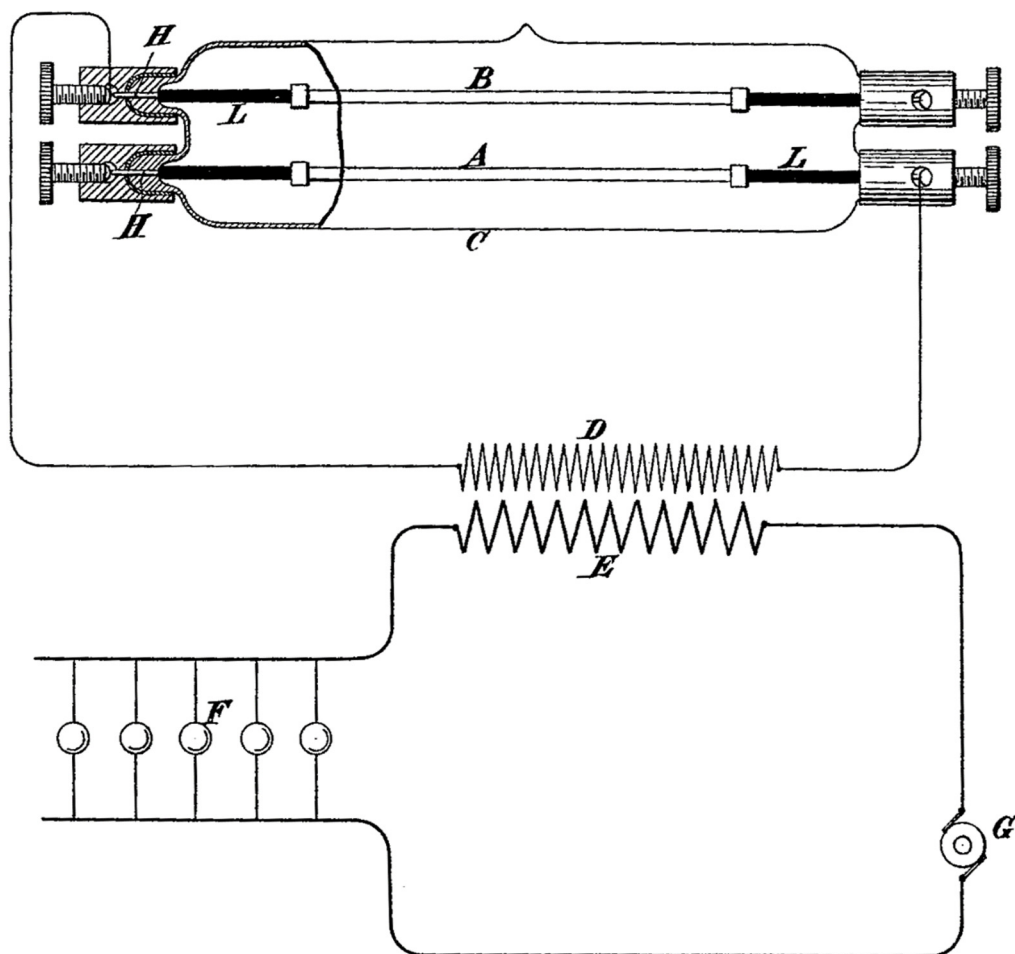
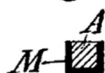


Fig. 2



Witnesses:
Raphael Netter
James H. Catlow

Inventor
Nikola Tesla
by Dumeau & Page
Attorneys

ELECTRICAL CONDUCTOR.

电导体

NIKOLA TESLA, OF NEW YORK, N. Y.

纽约州纽约市的尼古拉·特斯拉

SPECIFICATION forming part of Letters Patent No. 514,167, dated February 6, 1894.

Application filed January 2, 1892. Serial No. 416,773. (No model.)

该说明书形成了颁发于 1894 年 2 月 6 日编号为 514,167 的专利证书的一部分。

申请日期是 1892 年 1 月 2 日。序列号 416,773。(无模型)

To all whom it may concern:

致所有相关人士：

Be it known that I, NIKOLA TESLA, a citizen of the United States, residing at New York, in the county and State of New York, have invented a certain new and useful Improvements in Line Conductors for Systems of Electrical Distribution, of which the following is a specification, reference being had to the drawings accompanying and forming a part of the same.

众所周知，我，尼古拉·特斯拉，一名美国公民，居住在纽约州纽约郡纽约市的曼哈顿区，在配电系统的导线方面已经发明了某种新的和有用的改进，以下是该发明一个说明书，必须参考随附的图纸，它已形成该说明书的一部分。

In any system of electrical transmission or distribution in which currents of excessively high potential are employed, and more particularly, when the frequency is high, there is a dissipation of energy from the conductor or conductors of the line, due to the electrification of the atmosphere or other surrounding medium, or other causes.

在任何采用超高电位电流的输电或配电的系统中，特别是当频率很高时，由于大气或其他周围媒介的带电或其他原因，线路的一条或多条导线会产生能量损耗。

Heretofore it has been usual, in order to prevent loss by dissipation or interference by induction on line conductors, to insulate the same and enclose them in a continuous conducting sheathing or cover which has been connected with the ground by a good conducting path.

迄今为止，为了防止因线路导线上的感应引起的损耗或干扰，通常将其绝缘并封装在连续的导电护套或覆盖物中，该护套或覆盖物通过良好的导电路径与大地连接。

The object of my invention is to prevent loss on line conductors in a system of electrical transmission and distribution, more particularly such as that described by me in patent of June 23, 1891, No. 454,622, but in any other system in which alternating or, generally speaking, varying currents of excessively high

potential are employed.

我的发明的目的是在一个输电和配电的系统中防止导线的电能损耗，尤其是在 1891 年 6 月 23 日被授予的专利第 454,622 号中所描述的，但也可用于任何其它采用交流电或一般来说采用过高电位的变化电流的系统。

I have found that in these systems the use of a conducting sheath or screen around the line conductors and well grounded, or even brought into proximity to external conductors or large bodies, is attended by an actual and generally a serious loss of energy. I therefore maintain the sheath either entirely isolated or connected directly or inductively to the ground, through a path which will practically prevent the passage of currents over it. I have also found that when a continuous insulated sheath or screen is employed, there is greater liability to loss of energy by inductive action, for unless the sheath or screen be considerably shorter than the current waves passing in the conductor, electro-motive forces will be set up between different points in the sheath, which will result in the passage between such points of induced currents. I, therefore, divide up the sheath or screen into short lengths, very much shorter than the wave lengths of the current used, so that the grounding of any one of such lengths or the approach thereto of a large body will result in an inappreciable loss, or at most a small local draining of the energy, while the tendency of currents to flow between different points in the sheath is effectually overcome. The function of the sheath as a static screen for preventing the dissipation of the electric energy, however, requires for its complete effectiveness an uninterrupted conducting partition or screen around the conductor. I attain this respect in the case of a sectional screen, by causing the ends of the insulated divisions or sections of the same to overlap, interposing a suitable insulating material between the overlapping portions. By means of a conductor or conductors thus protected, I may transmit with slight loss and to great distances currents of very high potential and extremely high frequency.

我已经发现，在这些系统中，在线路导体周围使用导电护套或屏蔽层并良好接地，或者甚至靠近外部导体或大物体，都会伴随着实际的且通常严重的能量损失。因此，我保持护套完全被隔离或者直接地或感应地连接到地面，通过一个路径，该路径将实际上防止电流通过它。我还发现，当采用一个被连续绝缘的护套或屏蔽层时，更容易因感应作用而损失能量，因为除非护套或屏蔽比导体中通过的电流波短得多，否则在护套的不同点之间会产生电动势，这将导致感应电流在这些点之间通过。因此，我把护套或屏蔽分成短的长度，比使用的电流的波长要短得多，这样以来任何一个这样的长度的接地或接近一个大物体将导致一个微不足道的损失，或最多一个小的局部能量的消耗，而电流在护套中不同点之间流动的趋势被有效地克服。然而，护套作为用于防止电能耗散的一种静态屏蔽，要求在导体周围有一个不间断的导电的分隔或屏蔽才能完全有效。在分段屏蔽的情况下，通过使被绝缘的分段的端部重合，在重合部分之间插入一种合适的绝缘材料，我实现了这一点。通过被这样保护的一根或多根导线的工具，我可以以轻微的损耗将极高电位和极高频率的电流传输到很远的地方。

The invention is illustrated in the accompanying drawings in which—

本发明在附图中被展示，其中—

Figure 1 illustrates portions of the conductor with the earth connections above described. Fig. 2 is a sectional view of a portion of the conductor on an enlarged scale.

图 1 展示了具有上述接地连接的导体部分。图 2 是这种导体的一部分的放大截面图。

A is the central wire or conductor that carries the current.

A 是携带电流的中心导线或导体。

B is an insulating coating.

B 是绝缘包裹层。

C is a conducting sheathing or screen, which may be externally insulated, if so desired. This sheathing is divided up, as shown, into short lengths or sections, and the end of one section overlaps or telescopes with the end of the adjacent sections but is insulated therefrom by the material D.

C 是一种导电护套或屏蔽，如果需要，它可以是从外部绝缘。如图所示，该护套被分成短的长度或分段，并且一个部分的端部与相邻部分的端部重叠或叠套，但是通过材料 D 相互绝缘。

It is well known that a static screen, to be entirely effective as such, should have a ground connection, but it has been usual in such cases to provide a good electrical connection from the screen to earth. When a current of excessively high potential, however, is used, or when the frequency of the current is very high, such a connection is impracticable on account of the loss which follows. In such cases, therefore, I obtain the beneficial results of an earth connection while preventing the generally serious loss that would occur in the use of such currents, by providing between the sheath and the ground a path P of very high ohmic resistance or one containing a self-induction coil S properly determined with respect to the existing conditions so that it will effect the described result, or a condenser of very small capacity as shown at R. In such cases the sheathing or screen for practical purposes may be regarded as isolated from the ground, since by the character of the connection employed no appreciable loss results from the passage of current from the sheath to the ground.

众所周知，为了完全有效，静态屏蔽应该具有接地连接，但是在这种情况下通常会提供从屏蔽到地的良好电连接。然而，当使用过高电位的电流时，或者当电流频率非常高时，由于随之而来的损耗，这种连接是不切实际的。因此，在这种情况下，我获得了接地连接的有益效果，通过在护套和地之间提供具有非常高欧姆电阻的一个路径 P 或根据现有条件包含了适当确定的一个自感线圈 S 的一个路径 P，同时防止了在使用这种电流时通常会发生的严重损耗，从而实现了所述效果，或者提供了如 R 所示的容量非常小的一个电容器。在这种情况下，出于实用目的，护套或屏蔽可视为与地面隔离，因为根据所采用的连接特性，电流从护套流向地面不会产生明显的损耗。

No particular plan of construction need be followed in making up this conductor, and no special materials of the several kinds named need be used; the general construction and character of the conductor, apart from the particular features herein described, being entirely well understood by those skilled in the art.

在制造这种导体时，不需要遵循特定的构造方案，也不需要使用所提到的几种特殊材料；除

了这里描述的具体特征之外，导体的一般结构和特征完全被本领域技术人员所理解。

What I claim is—

我主张的是—

1. A conductor for electrical circuits, composed of a wire for carrying the current, an insulated coating or covering and a surrounding conducting sheath or screen divided into insulated sections, as set forth.

1、一种电路导体，由一条载流导线、一个绝缘涂层或覆盖层以及被分成被绝缘分段的一种周围导电护套或屏蔽层组成，如前所述。

2. A conductor for electrical circuits, composed of a wire for carrying the current, a coating or covering of insulating material and a surrounding conducting sheath or screen divided into insulated sections, the ends of which overlap, as set forth.

2、一种电路导体，由一条载流导线、一个绝缘材料涂层或覆盖层以及被分成被绝缘分段的一种周围导电护套或屏蔽层组成，其末端重叠，如上所述。

3. The combination of a wire or conductor for conveying electric currents, an insulated coating or covering therefore, a conducting sheath or screen surrounding the insulating coating and a connection between said sheathing and the ground containing a condenser of very small capacity or its equivalent.

3、用于传输电流的导线或导体、一个绝缘涂层或覆盖层、一个围绕绝缘涂层的导电护套或屏蔽层以及所述护套和接地之间的连接的组合，该连接包含非常小容量的电容器或其等效物。

NIKOLA TESLA.

尼古拉·特斯拉

Witnesses:

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PARKER W. PAGE.

见证人:

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(No Model.)

N. TESLA.
ELECTRICAL CONDUCTOR.

No. 514,167.

Patented Feb. 6, 1894.

Fig. 1

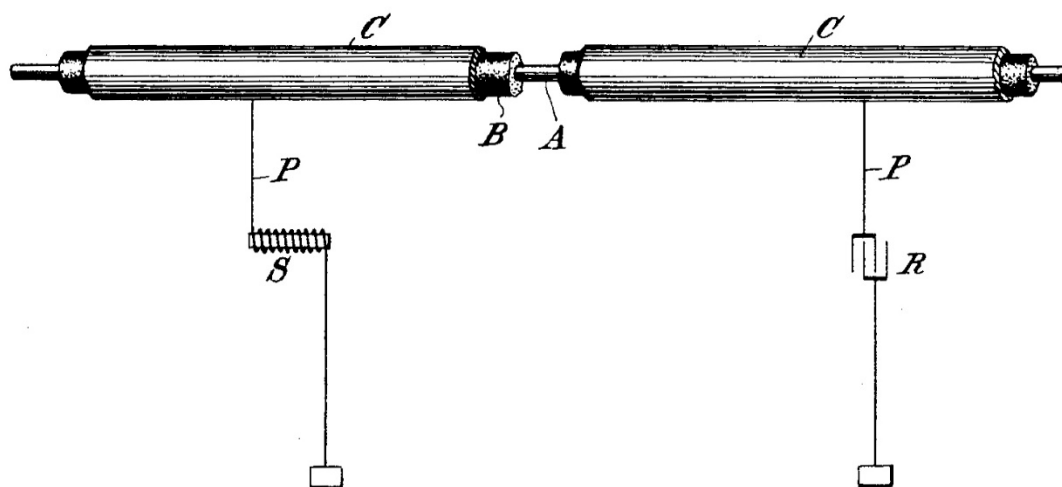
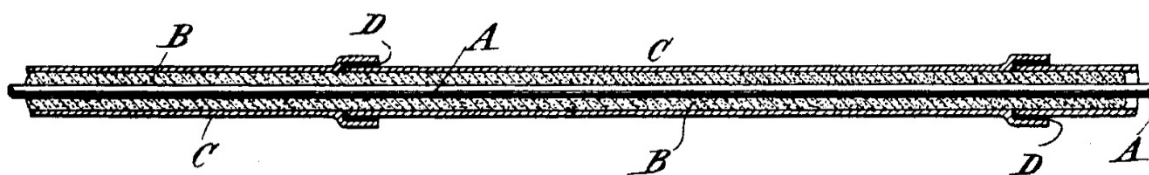


Fig. 2



Witnesses:

Raphael Vetter
Ernest Hopkinson

Inventor

Nikola Tesla
by *Duncan Hoge*
Attorneys

METHOD OF INSULATING ELECTRIC CONDUCTORS.

电导体绝缘的方法

NIKOLA TESLA, OF NEW YORK, N. Y.

纽约州纽约市的尼古拉·特斯拉

SPECIFICATION forming part of Reissued Letters Patent No. 11,865 dated October 23, 1900.
Original No. 655,838, dated August 14, 1900. Application for reissue filed September 21, 1900. Serial
No. 30,722. (No model.)

该说明书形成了 1900 年 10 月 23 日第 11865 号专利的再版说明书的组成部分。
原始编号为 655,838，日期为 1900 年 8 月 14 日。再版申请书于 1900 年 9 月 21 日提交。序
列号为 30,722。(没有模型)

To all whom it may concern:

致所有相关人士：

Be it known that I, NIKOLA TESLA, a citizen of the United States, residing in the borough of Manhattan, in the city, county, and State of New York, have invented certain new and useful Improvements in Methods of Insulating Electric Conductors, of which the following is a specification, reference being had to the accompanying drawings.

众所周知，我、尼古拉·特斯拉，一个美国公民，居住在纽约州纽约郡纽约市曼哈顿区，在电导体绝缘的方法方面发明了某种新的和有用的改进，以下是该发明一个说明书，必须参考随附的图纸。

It has long been known that many substances which are more or less conducting when in the fluid condition become insulators when solidified. Thus water, which is in a measure conducting, acquires insulating properties when converted into ice. The existing information on this subject, however, has been heretofore of a general nature only and chiefly derived from the original observations of Faraday, who estimated that the substances upon which he experimented, such as water and aqueous solutions, insulate an electrically-charged conductor about one hundred times better when rendered solid by freezing, and no attempt has been made to improve the quality of the insulation obtained by this means or to practically utilize it for such purposes as are contemplated in my present invention. In the course of my own investigations, more especially those of the electric properties of ice, I have discovered some novel and important facts, of which the more prominent are the following: first, that under certain conditions, when the leakage of the electric charge ordinarily taking place is rigorously prevented, ice proves itself to be a much better insulator than has heretofore appeared; second, that its insulating properties may be still further improved by the addition of other bodies to the water; third, that the dielectric strength of ice or other frozen aqueous substance increases with the reduction of temperature

and corresponding increase of hardness, and, fourth, that these bodies afford a still more effective insulation for conductors carrying intermittent or alternating currents, particularly of high rates, surprisingly-thin layers of ice being capable of withstanding electromotive forces of many hundreds and even thousands of volts. These and other observations have led me to the invention of a novel method of insulating conductors, rendered practicable by reason of the above facts and advantageous in the utilization of electrical energy for industrial and commercial purposes.

人们早就知道,许多物质在流动状态下或多或少是导电的,但凝固后就变成了绝缘体。因此,水在一定程度上是导电的,当它变成冰时,就获得了绝缘性能。然而,关于这个主题的现有信息迄今为止只是概括性的,主要源自法拉第的原始观察,他估计,他实验的物质,如水和水溶液,当它们通过冷冻呈现固体时,绝缘带电导体的能力原来大 100 倍,还没有试图改善通过这种方式获得的绝缘质量或实际利用它来实现我的发明预期的目的。在我自己的研究过程中,尤其是冰的电特性,我发现了一些新奇的和重要的事实,其中更突出的是以下:首先,在某些条件下,当通常发生的电荷泄漏被严格防止时,冰证明自己是一种比迄今为止所出现的绝缘体更好的绝缘体;第二,它的绝缘性能还可以通过在水中添加其他物体来进一步提高;第三,冰或其他冻结的含水物质的介电强度随着温度的降低和硬度的相应增加而增加,第四,这些物体为输送间歇电流或交流电流的导体提供了更有效的绝缘,特别是在高速率下,薄得令人惊讶的冰层能够承受数百甚至数千伏的电动势。这些结果和其他的观察使我发明了一种绝缘导体的新方法,由于上述事实,该方法变得可行,并且在出于工业和商业目的的电能利用中是有优势的。

This method consists in insulating an electric conductor by freezing or solidifying and maintaining in such state the material surrounding or contiguous to the conductor, using for the purpose a gaseous cooling agent circulating through one or more suitable channels extended through or in proximity to the said material.

该方法包括通过冷冻或凝固电导体周围的材料或邻近的导体的材料并将其维持在这种状态来使电导体被绝缘,为此目的,使用气体冷却剂循环通过一个或多个合适的通道,所述通道延伸穿过所述材料或邻近所述材料。

In the practical carrying out of my method I may employ a hollow conductor and pass the cooling agent through the same, thus freezing the water or other medium in contact with or close to such conductor, or I may use expressly for the circulation of the cooling agent an independent channel and freeze or solidify the adjacent substance in which any number of conductors may be embedded. The conductors may be bare or covered with some material which is capable of keeping them insulated when it is frozen or solidified. The frozen mass may be in direct touch with the surrounding medium, or it may be in a degree protected from contact with the same by an enclosure more or less impervious to heat. The cooling agent may be any kind of gas, as atmospheric air, oxygen, carbonic acid, ammonia, illuminating-gas, or hydrogen. It may be forced through the channel by pressure or suction produced mechanically or otherwise. It may be continually renewed or indefinitely used, being driven back and forth or steadily circulated in closed paths under any suitable conditions as regards pressure, density, temperature, and velocity.

在我的方法的实际实施中,我可以使用一个空心导体并使冷却剂通过该导体,从而冻结与该导体接触或接近的水或其他介质,或者我可以明确地使用独立通道用于冷却剂的循环,并冻

结或凝固在通道中的可被嵌入任何数量导体的邻近物质。导体可以是裸露的，也可以用某种材料覆盖，这种材料在冻结或凝固时能够保持导体被绝缘。冷冻物质可以与周围的介质直接接触，或者可以通过一个或多或少不透热的外壳在一定程度上防止与周围介质接触。冷却剂可以是任何种类的气体，如大气、氧气、碳酸、氨气、照明气体或氢气。可以通过机械或其他方式产生的压力或吸力迫使其通过通道。它可以不断更新或无限期使用，可以在任何合适的压力、密度、温度和速度条件下在封闭的路径中来回驱动或稳定循环。

To conduce to a better understanding of the invention, reference is now made to the accompanying drawings, in which—

为了有助于更好地理解本发明，现在参考附图，其中—

Figures 1, 3, 6, 7, 8, and 9 illustrate in longitudinal section typical ways of carrying out my invention; and Figs. 2, 4, 5, and 10, in section, or partly so, constructive details to be described.

图 1、3、6、7、8 和 9 展示了实施本发明的典型方式的纵向截面图；以及图 2、4、5 和 10，以截面或部分截面展示，将描述结构细节。

In Fig. 1, C is a hollow conductor, such as a steel tube, laid in a body of water and communicating with a reservoir r' , but electrically insulated from the same at j . A pump or compressor p , of any suitable construction connects r' with another similar tank r^2 , provided with an inlet-valve v^2 . The air or other gas which is used as the cooling agent entering through the valve v^2 is drawn through the tank r^2 and pump p into the reservoir r' , escaping thence through the conductor C under any desired pressure which may be regulated by a valve v' . Both the reservoirs r' and r^2 are kept at a low temperature by suitable means, as by coils or tubes $t' t'$ and $t^2 t^2$, through which any kind of refrigerating fluid may be circulated, some provision being preferably made for adjusting the flow of the same, as by valves v' . The gas continuously passing through the tube or conductor C being very cold will freeze and maintain in this state the water in contact with or adjacent to the conductor and so insulate it. Flanged bushings $i' i^2$, of non-conducting material, may be used to prevent the leakage of the current which would otherwise occur, owing to the formation of a superficial film of moisture over the ice projecting out of the water. The tube, being kept insulated by this means may then be employed in the manner of an ordinary telegraphic or other cable by connecting either or both of the terminals $b' b'$ in a circuit including the earth.

在图 1 中，C 是一个空心导体，例如一根钢管，被放置在水体中并与一个蓄水池 r' 连通，但是在 j 处与蓄水池 r' 电气绝缘。任何适合结构的泵或压缩机 p 将 r' 与另一个类似的蓄水池 r^2 连接，该蓄水池 r^2 设有入口阀 v^2 。通过阀 v^2 进入的用作冷却剂的空气或其它气体通过水箱 r^2 和泵 p 被抽入蓄水池 r' 中，并在可由阀 v' 调节的任何所需压力下通过导体 C 从蓄水池 r' 排出。蓄水池 r' 和 r^2 都通过合适的装置保持在低温，例如通过盘管或管 $t' t'$ 和 $t^2 t^2$ ，任何种类的制冷流体都可以通过它们进行循环，首选利用阀 v' 采取一些措施来调节制冷剂的流量。持续流过非常冷的管或导体 C 的气体将与导体接触或与导体邻近的水冻结或维持在这种冻结状态，从而使导体被绝缘。由非导电材料制成的带凸缘的套管 $i' i^2$ 可用于防止电流泄漏，否则，由于在伸出水面的冰上形成了一层薄薄的水汽，就会发生电流泄漏。通过这种方式保持被绝缘的管子可以以普通电报电缆或其它电缆的方式使用，即在包含接地的电路中连接一个或两个终端 $b' b'$ 。

In many cases it will be of advantage to cover the hollow conductor with a thick layer of some cheap material, as felt, this being indicated by C³ in Fig. 2. Such a covering, penetrable by water, would be ordinarily of little or no use; but when embedded in the ice it improves the insulating qualities of the same. In this instance it furthermore serves to greatly reduce the quantity of ice required, its rate of melting, and the influx of heat from the outside, thus diminishing the expenditure of energy necessary for the maintenance of normal working conditions. As regards this energy and other particulars of importance they will vary according to the special demands in each case.

在许多情况下，在空心导体上覆盖一层厚的廉价材料是有利的，如图 2 中的 C³ 所示。这种可被水渗透的覆盖物通常用处很小或没有用处；但是当嵌入冰中时，它提高了冰的绝缘质量。在这种情况下，它还可以大大减少所需的冰量、冰的融化速度以及从外部流入的热量，从而减少了维持正常工作条件所需的能量消耗。至于这种能量和其他重要的细节，它们将根据每种情况下的特殊需求而变化。

Generally considered, the cooling agent will have to carry away heat at a rate sufficient to keep the conductor at the desired temperature and to maintain a layer of the required thickness of the substance surrounding it in a frozen state, compensating continually for the heat flowing in through the layer and wall of the conductor and that generated by mechanical and electrical friction. To meet these conditions, its cooling capacity, which is dependent on the temperature, density, velocity, and specific heat, will be calculated by the help of data and formulae familiar to engineers. Air will be, as a rule, suitable for the use contemplated; but in exceptional instances some other gas, as hydrogen, may be resorted to, which will permit a much greater rate of cooling and a lower temperature to be reached. Obviously whichever gas be employed it should before entering the hollow conductor or channel be thoroughly dried and separated from all which by condensation and deposition or otherwise might cause an obstruction to its passage. For these purposes apparatus may be employed which is well known and which it is unnecessary to show in detail.

一般认为，冷却剂必须以足够的速率带走热量，来使得导体保持在所需的温度，并使一层所需厚度的包围导体的物质维持在冻结状态，持续抵消通过导体层和导体壁流入的热量以及由机械摩擦和电摩擦产生的热量。为了满足这些条件，冷却剂的取决于温度、密度、速度和比热的冷却能力，将借助于工程师熟悉的数据和公式来计算。空气通常适用于预期的用途；但是在特殊情况下，可以使用其它气体，如氢气，这样可以获得更高的冷却速度和更低的温度。显然，无论使用哪种气体，在进入空心导体或通道之前，都应被彻底干燥，并与所有因冷凝和沉积或其他原因可能阻碍其通过的气体分离。为了这些目的，可以使用众所周知的装置，没有必要详细展示。

Instead of being wasted at the distant station the cooling agent may be turned to some profitable use. Evidently in the industrial and commercial exploitation of my invention any kind of cooling agent capable of meeting the requirements may be conveyed from one to another station, and there utilized for refrigeration, power, heating, lighting, sanitation, chemical processes, or any other purpose to which it may lend itself, and thus the revenue of the plant may be increased.

冷却剂不会被浪费在远处的工作站，而是可以被转化为一些有益的用途。显然，在我的发明的工业开发和商业开发中，能够满足要求的任何种类的冷却剂可以从一个站输送到另一个站，并且在那里用于制冷、供电、加热、照明、卫生、化工或任何其他它可以贡献自己的目

的，并且因此工厂的收入可以增加。

As to the temperature of the conductor, it will be determined by the nature of its use and considerations of economy. For instance, if it be employed for the transmission of telegraphic messages, when the loss in electrical friction may be of no consequence, a very low temperature may not be required; but if it be used for transmitting large amounts of electrical energy, when the frictional waste may be a serious drawback, it will be desirable to keep it extremely cold. The attainment of this object will be facilitated by any provision for reducing as much as possible the flowing in of the heat from the surrounding medium. Clearly the lower the temperature of the conductor the smaller will be the loss in electrical friction; but, on the other hand, the colder the conductor the greater will be the influx of heat from the outside and the cost of the cooling agent. From such and similar considerations the temperature securing the highest economy will be ascertained.

至于导体的温度，将由它的使用性质和经济因素决定。例如，如果它被用来传输电报信息，当电摩擦中的损失可以是无关紧要时，可以不需要非常低的温度；但如果它被用来传输大量的电能，当摩擦浪费可能是一个严重的缺点时，就需要将它保持极冷。任何尽可能减少热量从周围介质流入的措施都有助于这个目的的实现。显然，导体的温度越低，电摩擦损失就越小；但是，另一方面，导体越冷，从外部流入的热量和冷却剂的成本就越大。从这样和类似的考虑中，可以确定获得最高经济性的温度。

Most frequently in the distribution of electricity for industrial purposes, as in my system of power transmission by alternate currents, more than one conductor will be required, and in such cases it may be convenient to circulate the cooling agent in a closed path formed by the conductors. A plan of this kind is illustrated in Fig. 3, in which C^1 and C^2 represent two hollow conductors embedded in a frozen mass underground and communicating, respectively, with the reservoirs R^1 and R^2 , which are connected by a reciprocating or other suitable pump P . Cooling coils or tubes $T^1 T^1$ and $T^2 T^2$ with regulating-valves $v^1 v^1$ are employed, which are similar to and serve the same purpose as those shown in Fig. 1. Other features of similarity, though unnecessary, are illustrated to facilitate an understanding of the plan. A three-way valve V^2 is provided, which when placed with its lever l as indicated allows the cooling agent to enter through the tubes $u^1 u^2$ and pump P , thus filling the reservoirs $R^1 R^2$ and hollow conductors $C^1 C^2$; but when turned ninety degrees the valve shuts off the communication to the outside through the tube u^1 and establishes a connection between the reservoir R^2 and pump P through the tubes u^2 and u^3 , thus permitting the cooling agent to be circulated in the closed path $C^1 C^2 R^2 u^3 u^2 P R^1$ by the action of the pump. Another valve V^1 of suitable construction, may be used for regulating the flow of the cooling agent. The conductors $C^1 C^2$ are insulated from the reservoirs $R^1 R^2$ and from each other at the joints $J^1 J^2 J^3$, and they are furthermore protected at the places where they enter and leave the ground by flanged bushings $I^1 I^1 I^2 I^2$, of insulating material, which extend into the frozen mass in order to prevent the current from leaking, as above explained. Binding-posts $B^1 B^1$ and $B^2 B^2$ are provided for connecting the conductors to the circuit at each station.

最常见的是在工业配电中，如在我的交流电输电系统中，需要一个以上的导体，在这种情况下，可以方便地在导体形成的一条闭合路径中循环冷却剂。这种类型的一个方案如图 3 所示，其中 C^1 和 C^2 表示埋在地下冻结物质中的两个空心导体，分别与蓄水池 R^1 和 R^2 连通，这两个蓄水池通过往复泵或其他合适的泵 P 连接到使用了带有调节阀 $v^1 v^1$ 的冷却盘管或管 $T^1 T^1$ 和 $T^2 T^2$ ，它们与图 1 中所示的盘管或管相似并用于相同的目的。其他相似的特征，虽然

不是必要的，但是为了便于理解该方案而被展示。提供了一个三通阀 V^2 ，当其杠杆 l 如图所示放置时，允许冷却剂通过管 $u^1 u^2$ 和泵 P 进入，从而填充容器 $R^1 R^2$ 和空心导体 $C^1 C^2$ ；但是当该阀转动 90 度时，它切断了通过管 u^1 与外部的连通，并通过管 u^2 和 u^3 建立了蓄水池 R^2 和泵 P 之间的连接，从而允许冷却剂在泵的作用下在闭合路径 $C^1 C^2 R^2 u^3 u^2 P R^1$ 中循环。具有适合结构的另一个阀 V^1 可用于调节冷却剂的流量。导体 $C^1 C^2$ 与蓄水池 $R^1 R^2$ 绝缘，并且在接头 $J^1 J^2 J^3$ 处彼此绝缘，并且它们还在它们进入和离开地面的地方受到绝缘材料的凸缘套管 $I^1 I^2 I^3$ 的保护，这些套管延伸到冻结体中，以便防止电流泄漏，如上所述。接线柱 $B^1 B^2$ 和 B^3 用于将导体连接到每个站的电路。

In laying the conductors, as $C^1 C^2$, whatever be their number, a trench will generally be dug and a trough, round or square, as T , of smaller dimensions than the trench, placed in the same, the intervening space being packed with some material (designated by $M M M$) more or less impervious to heat, as sawdust, ashes, or the like. Next the conductors will be put in position and temporarily supported in any convenient manner, and, finally, the trough will be filled with water or other substance W , which will be gradually frozen by circulating the cooling agent in the closed path, as before described. Usually the trench will not be level, but will follow the undulations of the ground, and this will make it necessary to subdivide the trough in sections or to effect the freezing of the substance filling it successively in parts. This being done and the conductors thus insulated and fixed, a layer of the same or similar material $M M M$ will be placed on the top and the whole covered with earth or pavement. The trough may be of metal, as sheet-iron, and in cases where the ground is used as the return-circuit it may serve as a main, or it may be of any kind of material more or less insulating. Figs. 4 and 5 illustrate in cross-section two such underground troughs T' and T'' , of sheet metal, with their adiathermanous enclosures, (designated M' and M'' , respectively,) each trough containing a single central hollow conductor, as C' and C'' . In the first case the insulation W' is supposed to be ice obtained by freezing water preferably freed of air in order to exclude the formation of dangerous bubbles or cavities, while in the second case the frozen mass W'' is some aqueous or other substance or mixture highly insulating when in this condition.

在铺设导体（如 $C^1 C^2$ ）的过程中，不管它们的数量，通常会挖一个沟槽，一个圆形或方形的槽（如 T ），比沟槽更小的尺寸，放置在该沟槽中，中间的空间填充一些材料（表示为 $M M M$ ）或多或少不透热，如锯屑、灰烬，或类似的东西。接下来，导体将被放置在适当的位置，并以任何方便的方式被临时支撑，最后，沟槽将被水或其他物质 W 填充，如前所述，水或其他物质 W 将在闭合路径中循环的冷却剂逐渐冻结。通常，沟槽不是水平的，而是随着地面的起伏而起伏，这就需要将沟槽分成几部分，或者使连续填充其中的物质分几部分冻结。完成后，导体因此被绝缘并被固定，一层相同或相似材料 $M M M$ 将放置在顶部，整体用土或路面覆盖。沟槽可以是金属的，如铁皮，在接地用作回路的情况下，它可以作为一条干线，或者它可以是任何种类的或多或少绝缘的材料。图 4 和图 5 展示了两个这样的金属板制成的地下沟槽 T' 和 T'' ，以及它们的绝热外壳（分别表示为 M' 和 M'' ），每个沟槽包含一个中心空心导体，如 C' 和 C'' 。在第一种情况下，绝缘材料 W' 应该是通过冷冻首选不含空气的水而获得的冰，以便排除危险的气泡或空穴的形成，而在第二种情况下，冷冻物质 W'' 是在这种条件下高度绝缘的一些含水物质或其它物质或混合物。

It should be stated that in many instances it may be practicable to dispense with a trough by resorting to simple expedients in the placing and insulating of the conductors. In fact, for some purposes it may be sufficient to simply cover the latter with a moist mass, as cement or other plastic material, which so long as it is kept at a very low temperature and frozen hard will afford adequate insulation.

应该指出的是，在许多情况下，通过在放置导体和绝缘导体时采取简单的权宜之计来省去沟槽是可行的。事实上，对于某些目的来说，用潮湿的物质，如水泥或其他塑料材料，简单地覆盖后者就足够了，只要保持在非常低的温度和足够的冻结硬度将提供足够的绝缘。

Another typical way of carrying out my invention, to which reference has already been made, is shown in Fig. 6, which represents the cross-section of a trough, the same in other respects as those before shown, but containing instead of a hollow conductor any kind of pipe or conduit L. The cooling agent may be driven in any convenient manner through the pipe for the purpose of freezing the water or other substance filling the trough, thus insulating and fixing a number of conductors c c c. Such a plan may be particularly suitable in cities for insulating and fixing telegraph and telephone wires or the like. In such cases an exceedingly-low temperature of the cooling agent may not be required, and the insulation will be obtained at the expense of little power. The conduit L may, however, be used simultaneously for conveying and distributing any kind of gaseous cooling agent for which there is a demand through the district. Obviously two such conduits may be provided and used in a similar manner as the conductors C' C².

已经参考过的实施我的发明的另一种典型方式如图 6 所示，该图展示了沟槽的横截面，在其它方面与前面所示相同，但是包含任何种类的管道或导管 L 而不是空心导体，冷却剂可以以任何方便的方式被驱动通过管道，目的是冻结填充沟槽的水或其他物质，从而绝缘和固定多个导体 c c c。这种方案可能特别适合于在城市中用来绝缘和固定电报和电话线等。在这种情况下，冷却剂可以不需要极低的温度，并且将以很少的功率为代价获得绝缘。然而，导管 L 可以同时用于输送和分配任何种类的气态冷却剂，这在整个地区是有需求的。显然，可以提供两个这样的导管，并以与导体 C' C² 类似的方式使用。

It will often be desirable to place in the same trough a great number of wires or conductors serving for a variety of purposes. In such a case a plan may be adopted which is illustrated in Fig. 7, showing a trough similar to that in Fig. 6 with the conductors in cross-section. The cooling agent may be in this instance circulated, as in Fig. 3 or otherwise, through the two hollow conductors C³ and C⁴, which if found advantageous may be covered with a layer of cheap material m m, such as will improve their insulation, but not prevent the freezing or solidification of the surrounding substance W. The tubular conductors C' C², preferably of iron, may then serve to convey heavy currents for supplying light and power, while the small ones c' c' c', embedded in the ice or frozen mass, may be used for any other purposes.

通常希望在同一沟槽中放置大量用于各种目的的导线或导体。在这种情况下，可以采用图 7 所示的方案，图 7 展示了类似于图 6 的沟槽，其中导体处于横截面中。在这种情况下，冷却剂可以如图 3 或其他图，通过两个空心导体 C³ 和 C⁴ 循环，如果发现有利的话，可以用一层便宜的材料 m 覆盖，例如将改善它们的绝缘，但是不能防止周围物质 W 的冻结或凝固管状导体 C' C²，最好是铁的，可以用来传输大电流以提供光和电，而嵌入冰或冻结物质中的小导体 c' c' c' 可以用于任何其他目的。

While my invention contemplates, chiefly, the insulation of conductors employed in the transmission of electrical energy to a distance, it may be, obviously, otherwise usefully applied. In some instances, for example, it may be desirable to insulate and support a conductor in places as is ordinarily done by means of glass or porcelain insulators. This may be effected in many ways by conveying a cooling agent

either through the conductor or through an independent channel and freezing or solidifying any kind of substance, thus enabling it to serve the purpose. Such an artificial insulating-support is illustrated in Fig. 8, in which a represents a vessel filled with water or other substance w , frozen by the agent circulating through the hollow conductor C' , which is thus insulated and supported. To improve the insulation on the top, where it is most liable to give way, a layer of some substance w' , as oil, may be used, and the conductor may be covered near the support with insulation $i i$, as shown, the same extending into the oil, for reasons well understood.

虽然我的发明主要考虑了用于向远处传输电能的导体的绝缘,但显然它也可以有其他有用的应用。例如,在某些情况下,可能需要在某些地方绝缘和支撑一个导体,这通常是通过玻璃或陶瓷绝缘体来实现的。这可以通过多种方式实现,通过导体或通过一个独立的通道输送冷却剂,并冷冻或固化任何种类的物质,从而使其能够达到目的。这种人造绝缘支撑在图 8 中被展示出,其中 a 表示充满水或其他物质 w 的容器,被通过中空导体 C' 循环的冷冻剂冻结,因此导体 C' 被绝缘并被支撑。在顶部最容易塌陷,为了改善顶部的绝缘,可以使用一层某种物质 w' , 如油,并且导体可以在支架附近覆盖有绝缘 $i i$, 如图所示,由于众所周知的原因,绝缘 $i i$ 延伸到油中。

Another typical application of my invention is shown in Fig. 9, in which P' and S' represent, respectively, the primary and secondary conductors, bare or insulated, of a transformers, which are wound on a core N and immersed in water or other substance W , containing a jar H , and, as before stated, preferably freed of air by boiling or otherwise. The cooling agent is circulated in any convenient manner, as through the hollow primary P' , for the purpose of freezing the substance W . Flanged bushings $d d$ and oil-cups $e e$, extending into the frozen mass, illustrate suitable means for insulating the ends of the two conductors and preventing the leakage of the currents. A transformer as described is especially fitted for use with currents of high frequency when a low temperature of the conductors is particularly desirable, and ice affords an exceptionally-effective insulation.

我的发明的另一个典型应用如图 9 所示,其中 P' 和 S' 分别代表变压器的初级导体和次级导体,裸露的或绝缘的,它们缠绕在磁芯 N 上并浸在水中或其它物质 W 中,被容纳在一个罐 H 中,如前所述,最好通过煮沸或其它方法除去空气。为了冷冻物质 W , 冷却剂以任何方便的方式循环,例如通过中空的初级 P' 。延伸到冻结物质中的凸缘套管 $d d$ 和油杯 $e e$ 说明了用于绝缘两个导体的末端和防止电流泄漏的适合方法。当导体的低温是特别需要的,并且冰提供了特别有效的绝缘时,所描述的变压器特别适合用于高频电流。

It will be understood that my invention may be applied in many other ways, that the special means here described will be greatly varied according to the necessities, and that in each case many expedients will be adopted which are well known to engineers and electricians and on which it is unnecessary to dwell. However, it may be useful to state that in some instances a special provision will have to be made for effecting a uniform cooling of the substance surrounding the conductor throughout its length. Assuming in Fig. 1 the cooling agent to escape at the distant end freely into the atmosphere or into a reservoir maintained at low pressure, it will in passing through the hollow conductor C move with a velocity steadily increasing toward the end, expanding isothermally, or nearly so, and hence it will cause an approximately-uniform formation of ice along the conductor. In the plan illustrated in Fig. 3 a similar result will be in a measure attained, owing to the compensating effect of the hollow conductor C' and C'' , which may be still further enhanced by reversing periodically the direction of the flow in any

convenient manner; but in many cases special arrangements will have to be employed to render the cooling more or less uniform. For instance, referring to Figs. 4, 5, and 6, instead of a single channel two concentric channels L^1 and L^2 may be provided and the cooling agent passed through one and returned through the other, as indicated, diagrammatically, in Fig. 10. In this and any similar arrangement when the flow takes place in opposite directions the object aimed at will be more completely attained by reducing the temperature of the circulating cooling agent at the distant station, which may be done by simply expanding it into a large reservoir, as R^3 , or cooling it by means of a tube or coil T^3 or otherwise. Evidently in the case illustrated the concentric tubes may be used as independent conductors if insulated from each other and from the ground by the frozen or solidified substance.

可以理解的是, 我的发明可以以许多其他方式应用, 这里描述的特定装置将根据需要而有很大变化, 并且在每种情况下, 将采用许多工程师和电工熟知的权宜之计, 并且没有必要详述。然而, 可能有必要说明, 在某些情况下, 必须采取特殊措施来实现导体周围物质在其整个长度上的均匀冷却。假设在图 1 中, 冷却剂在远端自由地逸出到大气中或进入维持在低压下的容器中, 它将在穿过中空导管 C 时以稳定增加的速度向端部移动, 等温膨胀, 或接近等温膨胀, 因此它将导致沿着导管近似均匀地形成冰。在图 3 所示的方案中, 由于中空导体 C^1 和 C^2 的抵消效应, 将在一定程度上获得类似的结果, 这可以通过以任何方便的方式周期性地反转流动方向来进一步增强; 但在许多情况下, 必须采用特殊布置来使冷却或多或少变得均匀。例如, 参考图 4、5 和 6, 而不是单个通道, 可以提供两个同心通道 L^1 和 L^2 , 冷却剂通过一个通道前进并通过另一个通道返回, 如图 10 中示意性地展示。在这种布置和任何类似的布置中, 当流动发生在相反方向时, 通过降低在远处站的循环中的冷却剂的温度, 可以更完全地实现所要达到的目的, 这可以通过简单地将冷却剂膨胀到一个大的容器中来实现, 如 R^3 , 或者通过管或盘管 T^3 或其它方式来使冷却剂降温。显然, 在所示的情况下, 如果同心管 (同心的不同导管) 通过冻结或固化的物质彼此绝缘并与地面绝缘, 则同心管可以用作独立的导体。

Generally in the transmission of electrical energy in large amounts, when the quantity of heat to be carried off may be considerable, refrigerating apparatus thoroughly protected against the inflow of heat from the outside, as usual, will be employed at both the stations and when the distance between them is very great also at intermediate points, the machinery being advantageously operated by the currents transmitted or cooling agent conveyed.

通常, 在大量电能传输中, 当要带走的热量可能相当大时, 通常在两个站都将使用完全防止热量从外部流入的制冷设备, 并且当它们之间的距离非常大时, 在中间点也要如此, 机器由传输的电流或输送的冷却剂有优势地操作。

In such cases a fairly-uniform freezing of the insulating substance will be attained without difficulty by the compensating effect of the oppositely-circulating cooling agents.

在这种情况下, 通过反向循环冷却剂的抵消效应, 可以毫无困难地获得绝缘物质的相当均匀的冻结。

In large plants of this kind when the saving of electrical energy in the transmission is the most important consideration or when the chief object is to reduce the cost of the mains by the employment of cheap metal, as iron or otherwise, every effort will be made to maintain the conductors at the lowest possible

temperature, and well-known refrigeration processes, as those based on the regenerative principle, may be resorted to, and in this and any other case the hollow conductors or channels instead of merely serving the purpose of conveying the cooling agent may themselves form active parts of the refrigerating apparatus.

在这种大型发电厂中，当节约传输中的电能是最重要的考虑因素时，或者当主要目的是通过使用廉价金属（如铁或其他金属）来降低电力网的成本时，将尽一切努力将导体保持在尽可能低的温度，并且可以采用众所周知的制冷过程，如基于再生原理的制冷过程，并且在这种情况下和任何其它情况下，空心导体或通道不仅仅用于输送冷却剂，它们本身可以形成制冷设备的有效部件。

From the above description it will be readily seen that my invention forms a fundamental departure in the principle from the established methods of insulating conductors employed in the industrial and commercial application of electricity. It aims, broadly, at obtaining insulation by the continuous expenditure of a moderate amount of energy instead of securing it only by virtue of an inherent physical property of the material used as heretofore. More especially, its object is to provide, when and wherever required, insulation of high quality, of any desired thickness, and exceptionally cheap, and to enable the transmission of electrical energy under conditions of economy heretofore unattainable and at distances until now impracticable by dispensing with the necessity of using costly conductors and insulators.

从上面的描述中可以容易地看出，我的发明在原理上与工业和商业用电中所采用的绝缘导体的既定方法形成了根本的不同。概括地说，它的目的是通过持续消耗适量的能量来获得绝缘，而不是仅仅依靠迄今为止所用材料的固有物理特性来获得绝缘。更具体地说，其目的是在需要的时间和地方提供具有任何期望的厚度、并且特别便宜的高质量的绝缘，并且通过免除了使用昂贵的导体和绝缘体的必要性，能够在迄今为止无法实现的经济条件下和在迄今为止无法实现的距离上传输电能。

What I claim as my invention is—

我主张我的发明是—

1. The method of insulating electric conductors herein described which consists in imparting insulating properties to material surrounding or contiguous to the said conductor by the continued action thereon of a gaseous cooling agent, as set forth.

1、在此描述的使电导体绝缘的方法，包括通过气态冷却剂在其上的持续作用，赋予所述导体周围或邻近的材料绝缘性能，如上所述。

2. The method of insulating electric conductors herein described which consists in reducing to and maintaining in a frozen or solidified condition the material surrounding or contiguous to the said conductor by the action thereon of a gaseous cooling agent maintaining in circulation through one or more channels as set forth.

2、在此描述的使电导体绝缘的方法，包括通过气态冷却剂在其上的作用将所述导体周围或附近的材料减少并保持在冻结或凝固状态，所述气态冷却剂通过一个或多个通道维持循环，

如上所述。

3. The method of insulating electric conductors herein described which consists in surrounding or supporting the conductor by material which acquires insulating properties when in a frozen solidified state, and maintaining the material in such a state by the circulation through one or more channels extending through it of a gaseous cooling agent, as set forth.

3、在此描述的使电导体绝缘的方法，包括用在一个冷冻固化状态下获得绝缘性能的材料来包围或支撑导体，并通过气态冷却剂在一个或多个贯穿该材料的通道中的循环将材料保持在这种状态，如上所述。

4. The method of insulating an electric conductor which consists in surrounding or supporting said conductor by a material which acquires insulating properties when frozen or solidified, and maintaining the material in such state by passing a gaseous cooling agent continuously through a channel in said conductor, as set forth.

4、一种使电导体绝缘的方法，包括用一种在冻结或固化时获得绝缘性能的材料来包围或支撑所述导体，并通过使气态冷却剂持续通过所述导体中的通道来保持该材料处于这种状态，如前所述。

5. The method of insulating electric conductors, which consists in surrounding or supporting the said conductors by a material which acquires insulating properties when in a frozen or solidified state, and maintaining the material in such state by the continued application thereto of a gaseous cooling agent, as set forth.

5、一种使电导体绝缘的方法，该方法包括用一种在冻结或凝固状态下具有绝缘性能的材料来包围或支撑所述导体，并通过向该材料持续应用气态冷却剂来保持该材料处于上述状态。

6. The method of insulating conductors herein set forth which consists in surrounding or supporting the conductors by a material which acquires insulating properties when in a frozen or solidified state, and maintaining the material in such state by the circulation of a gaseous cooling agent through a circuit of pipes or tubes extending through the said material as set forth.

6、在此阐述的绝缘导体的方法，包括用在冻结或固化状态下获得绝缘性能的材料来包围或支撑该导体，并通过气态冷却剂在延伸穿过所述材料的管道或导管回路中的循环将材料保持在这种状态。

7. The method of insulating electric conductors which consists in laying or supporting the conductors in a trough or conduit filling the trough with a material which acquires insulating properties when frozen or solidified, and then causing a gaseous cooling agent to circulate through one or more channels extending through the material in the trough so as to freeze or solidifying the material, as set forth.

7、绝缘电导体的方法，包括将导体放置或支撑在沟槽或导管中，用冷冻或固化时获得绝缘性能的材料填充沟槽或导管，然后使气态冷却剂循环通过一个或多个延伸穿过沟槽中材料的通道，以便冷冻或固化材料，如上所述。

8. The method of insulating electric conductors which consists in embedding the same in a moist or plastic compound which acquires insulating properties when in a frozen or solidified state, and maintaining the compound in such state by circulating a gaseous cooling agent through one or more channels extending through the compound, as set forth.

8、使电导体绝缘的方法，包括将电导体嵌入一种潮湿的或塑料化合物中，当处于冻结或固化状态时，该化合物获得绝缘性能，并通过使气态冷却剂循环通过一个或多个延伸穿过该化合物的通道来保持该化合物处于这种状态，如上所述。

9. The method of insulating electric conductors which consist in laying or supporting the conductors in a trough or conduit, filling the trough with a material which acquires insulating properties when frozen or solidified, protecting the trough from the surrounding medium in which it is laid by an adiabatic enclosure, and then freezing or solidifying the material surrounding the conductors and maintaining the same in such state by circulating a gaseous cooling agent through one or more channels extending through the same, as set forth.

9、使电导体绝缘的方法，包括将导体放置或支撑在沟槽或导管中，用冷冻或固化时获得绝缘性能的材料填充沟槽或导管，通过绝热外壳保护沟槽免受环境介质的影响，然后冷冻或固化导体周围的材料，并通过使气态冷却剂循环通过延伸穿过导体的一个或多个通道来使材料保持该状态，如上所述。

NIKOLA TESLA.

尼古拉·特斯拉

Witnesses:

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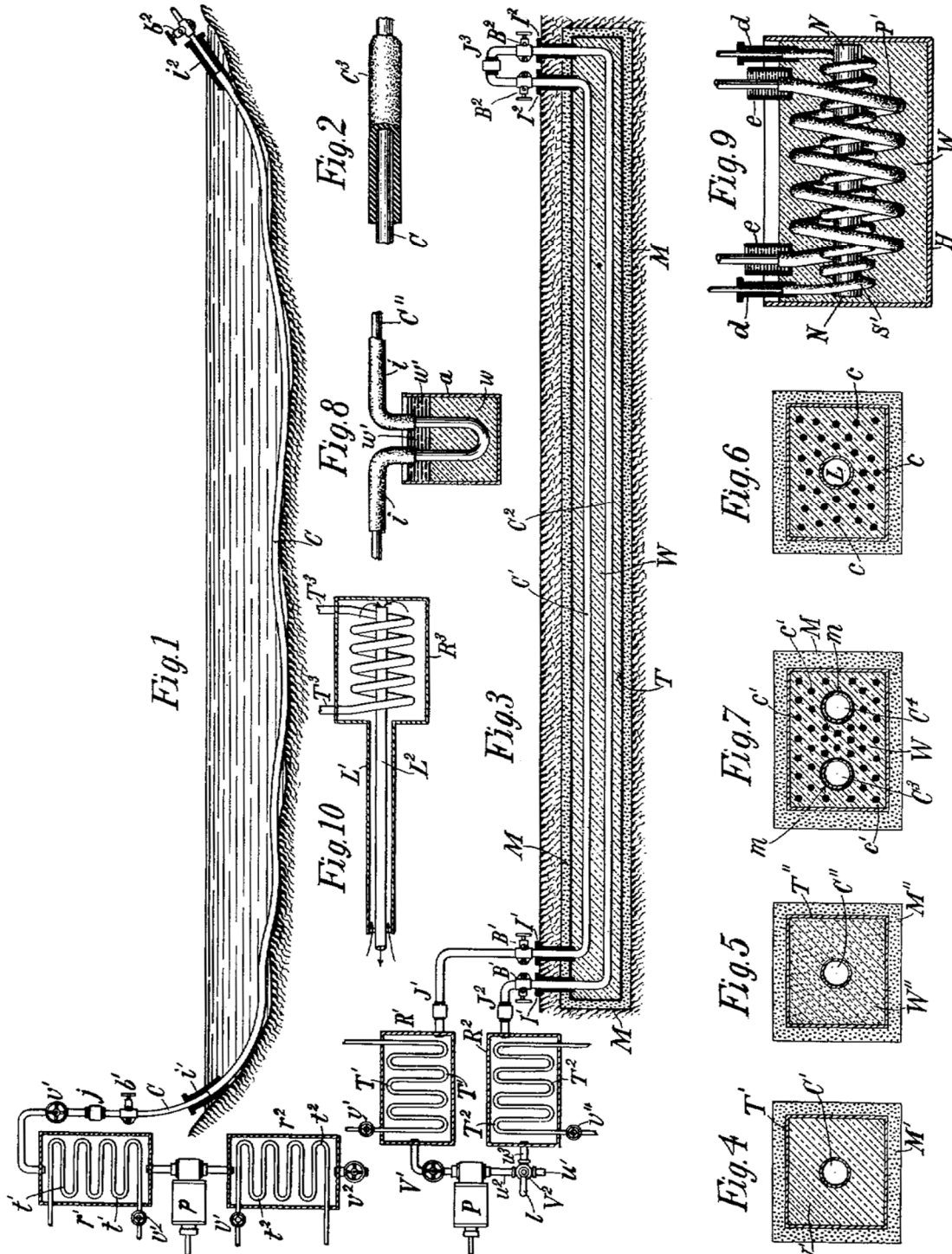
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METHOD OF INSULATING ELECTRIC CONDUCTORS.

(Application filed Sept. 21, 1900.)



Witnesses:
Raphaël Petter
Benjamin Miller

Nikola Tesla Inventor
 by *Herb Page & Cooper* Attys.

METHOD OF INSULATING ELECTRIC CONDUCTORS.

电导体绝缘的方法

NIKOLA TESLA, OF NEW YORK, N. Y.

纽约州纽约市的尼古拉·特斯拉

SPECIFICATION forming part of Letters Patent No. 655,838, dated April 14, 1900.

Application filed June 15, 1900. Serial No. 20,405. (No specimens.)

该说明书形成了颁发于1900年4月14日编号为655,838的专利证书的一部分。

申请于1900年6月15日提交。序列号为20,405。(没有样本。)

To all whom it may concern:

致所有相关人士：

Be it known that I, NIKOLA TESLA, a citizen of the United States, residing in the borough of Manhattan, in the city, county, and State of New York, have invented certain new and useful Improvements in Methods of Insulating Electric Conductors, of which the following is a specification, reference being had to the accompanying drawings.

众所周知，我、尼古拉·特斯拉，一个美国公民，居住在纽约州纽约郡纽约市曼哈顿区，在电导体绝缘的方法方面发明了某种新的和有用的改进，以下是该发明一个说明书，必须参考随附的参考图纸。

It has long been known that many substances which are more or less conducting when in the fluid condition become insulators when solidified. Thus water, which is in a measure conducting, acquires insulating properties when converted into ice. The existing information on this subject, however, has been heretofore of a general nature only and chiefly derived from the original observations of Faraday, who estimated that the substances upon which he experimented, such as water and aqueous solutions, insulate an electrically-charged conductor about one hundred times better when rendered solid by freezing, and no attempt has been made to improve the quality of the insulation obtained by this means or to practically utilize it for such purposes as are contemplated in my present invention. In the course of my own investigations, more especially those of the electric properties of ice, I have discovered some novel and important facts, of which the more prominent are the following: first, that under certain conditions, when the leakage of the electric charge ordinarily taking place is rigorously prevented, ice proves itself to be a much better insulator than has heretofore appeared; second, that its insulating properties may be still further improved by the addition of other bodies to the water; third, that the dielectric strength of ice or other frozen aqueous substance increases with the reduction of temperature and corresponding increase of hardness, and, fourth, that these bodies afford a still more effective insulation for conductors carrying intermittent or alternating currents, particularly of high rates,

surprisingly-thin layers of ice being capable of withstanding electromotive forces of many hundreds and even thousands of volts. These and other observations have led me to the invention of a novel method of insulating conductors, rendered practicable by reason of the above facts and advantageous in the utilization of electrical energy for industrial and commercial purposes. Broadly stated, the method consists in insulating an electric conductor by freezing or solidifying and maintaining in such state, by the circulation of a cooling agent, the material surrounding or contiguous to the conductor.

人们早就知道,许多物质在流动状态下或多或少是导电的,但凝固后就变成了绝缘体。因此,水在一定程度上是导电的,当它变成冰时,就获得了绝缘属性。然而,关于这个主题的现有信息迄今为止只是概括性的,主要源自法拉第的原始观察,他估计,他实验的物质,如水和水溶液,当它们通过冷冻呈现固体时,绝缘带电导体的能力原来大 100 倍,还没有试图改善通过这种方式获得的绝缘质量或实际利用它来实现我的发明预期的目的。在我自己的研究过程中,尤其是冰的电特性,我发现了一些新奇的和重要的事实,其中更突出的是以下:首先,在某些条件下,当通常发生的电荷泄漏被严格防止时,冰证明自己是一种比迄今为止所出现的绝缘体更好的绝缘体;第二,它的绝缘性能还可以通过在水中添加其他物体来进一步提高;第三,冰或其他冻结的含水物质的介电强度随着温度的降低和硬度的相应增加而增加,第四,这些物体为输送间歇电流或交流电流的导体提供了更有效的绝缘,特别是在高速率下,薄得令人惊讶的冰层能够承受数百甚至数千伏的电动势。这些结果和其他的观察使我发明了一种绝缘导体的新方法,由于上述事实,该方法变得可行,并且在出于工业和商业目的的电能利用中是有优势的。概括地说,该方法包括通过冷却剂的循环,使电导体周围的或邻近导体的材料冷冻或固化并维持在这种状态,从而使电导体绝缘。

In the practical carrying out of my method I may employ a hollow conductor and pass the cooling agent through the same, thus freezing the water or other medium in contact with or close to such conductor, or I may use expressly for the circulation of the cooling agent an independent channel and freeze or solidify the adjacent substance, in which any number of conductors may be embedded. The conductors may be bare or covered with some material which is capable of keeping them insulated when it is frozen or solidified. The frozen mass may be in direct touch with the surrounding medium or it may be in a degree protected from contact with the same by an enclosure more or less impervious to heat. The cooling agent may be any kind of liquid, preferably of low freezing-point, as brine, or it may be a gas, as atmospheric air, oxygen, carbonic acid, ammonia, illuminating-gas, or hydrogen. It may be forced through the channel by gravity, pressure, or suction, produced mechanically or otherwise, or by any other kind of force. It may be continually renewed or indefinitely used by being alternately volatilized and condensed or evaporated and absorbed and mechanically driven back and forth or steadily circulated in a closed path under any suitable conditions as regards pressure, density, temperature, and velocity.

在我的方法的实际实施中,我可以使用的空心导体并使冷却剂通过该导体,从而冻结与该导体接触或接近的水或其他介质,或者我可以专门使用一个独立通道用于冷却剂的循环,并冻结或凝固在通道中可被嵌入的任何数量的导体的邻近物质。导体可以是裸露的,也可以用某种材料覆盖,这种材料在冻结或凝固时能够保持导体被绝缘。冷冻物质可以与周围的介质直接接触,或者可以通过一个或多或少不透热的外壳在一定程度上防止与周围介质接触。冷却剂可以是任何种类的液体,最好低凝固点的液体,如盐水,或者也可以是气体,如大气、氧气、碳酸、氨、照明气体或氢气。它可以通过重力、压力或吸力、机械力或其他方式产生的力或任何其他类型的力被强制通过通道。通过交替地挥发和冷凝,或蒸发和吸收,并在压

力、密度、温度和速度等任何合适的条件下来回被机械地驱动或在封闭的路径中稳定地循环，它可以持续更新或无限期地使用。

To conduce to a better understanding of the invention, reference is now made to the accompanying drawings, in which—

为了有助于更好地理解本发明，现在参考附图，其中—

Figures 1, 3, 6, 7, 8, and 9 illustrate in longitudinal section typical ways of carrying out my invention; and Figs. 2, 4, 5, and 10, in section or partly so, constructive details to be described.

图 1、3、6、7、8 和 9 展示了实施本发明的典型方式的纵向截面图；以及图 2、4、5 和 10，以截面或部分截面展示，将描述结构细节。

In Fig. 1, C is a hollow conductor, such as a steel tube, laid in a body of water and communicating with a reservoir r^1 , but electrically insulated from the same at j. A pump or compressor p of any suitable construction connects r^1 with another similar tank r^2 , provided with an inlet-valve v^2 . The air or other gas which is used as the cooling agent entering through the valve v^2 is drawn through the tank r^2 and pump p into the reservoir r^1 , escaping thence through the conductor C under any desired pressure, which may be regulated by a valve v^1 . Both the reservoirs r^1 and r^2 are kept at a low temperature by suitable means, as by coils or tubes t^1 t^1 and t^2 t^2 , through which any kind of refrigerating fluid may be circulated, some provision being preferably made for adjusting the flow of the same, as by valves v^1 . The gas continuously passing through the tube or conductor C being very cold will freeze and maintain in this state the water in contact with or adjacent to the conductor and so insulate it. Flanged bushings i^1 i^2 of non-conducting material may be used to prevent the leakage of the current which would otherwise occur, owing to the formation of a superficial film of moisture over the ice projecting out of the water. The tube, being kept insulated by this means, may then be employed in the manner of an ordinary telegraphic or other cable by connecting either or both of the terminals b^1 b^2 in a circuit including the earth.

在图 1 中，C 是一个空心导体，例如一根钢管，被放置在水体中并与一个蓄水池 r^1 连通，但是在 j 处与蓄水池 r^1 电绝缘。任何适合结构的泵或压缩机 p 将 r^1 与另一个类似的蓄水池 r^2 连接，该蓄水池 r^2 设有入口阀 v^2 。通过阀 v^2 进入的用作冷却剂的空气或其它气体通过水箱 r^2 和泵 p 被抽入蓄水池 r^1 中，并在可由阀 v^1 调节的任何所需压力下通过导体 C 从蓄水池 r^1 排出。蓄水池 r^1 和 r^2 都通过合适的装置保持在低温，例如通过盘管或管 t^1 t^1 和 t^2 t^2 ，任何种类的制冷流体都可以通过它们进行循环，首选利用阀 v^1 采取一些措施来调制冷剂的流量。持续流过非常冷的管或导体 C 的气体将与导体接触或与导体邻近的水冻结或维持在这种冻结状态，从而使导体被绝缘。由非导电材料制成的带凸缘的套管 i^1 i^2 可用于防止电流泄漏，否则，由于在伸出水面的冰上形成了一层薄薄的水汽，就会发生电流泄漏。通过这种方式保持被绝缘的管子可以以普通电报电缆或其它电缆的方式使用，即在包含接地的电路中连接一个或两个终端 b^1 b^2 。

In many cases it will be of advantage to cover the hollow conductor with a thick layer of some cheap material, as felt, this being indicated by C^3 in Fig. 2. Such a covering, penetrable by water, would be ordinarily of little or no use; but when embedded in the ice it improves the insulating qualities of the

same. In this instance it furthermore serves to greatly reduce the quantity of ice required, its rate of melting, and the influx of heat from the outside, thus diminishing the expenditure of energy necessary for the maintenance of normal working conditions. As regards this energy and other particulars of importance they will vary according to the special demands in each case.

在许多情况下，在空心导体上覆盖一层厚的廉价材料是有利的，如图 2 中的 C³ 所示。这种可被水渗透的覆盖物通常用处很小或没有用处；但是当嵌入冰中时，它提高了冰的绝缘质量。在这种情况下，它还可以大大减少所需的冰量、冰的融化速度以及从外部流入的热量，从而减少了维持正常工作条件所需的能量消耗。至于这种能量和其他重要的细节，它们将根据每种情况下的特殊需求而变化。

Generally considered, the cooling agent will have to carry away heat at a rate sufficient to keep the conductor at the desired temperature and to maintain a layer of the required thickness of the substance surrounding it in a frozen state, compensating continually for the heat flowing in through the layer and wall of the conductor and that generated by mechanical and electrical friction. To meet these conditions, its cooling capacity, which is dependent on the temperature, density, velocity, and specific heat, will be calculated by the help of data and formulae familiar to engineers. Air will be, as a rule, suitable for the use contemplated; but in exceptional instances some other gas, as hydrogen, may be resorted to, which will permit a much greater rate of cooling and a lower temperature to be reached. Obviously whichever gas be employed it should before entering the hollow conductor or channel be thoroughly dried and separated from all which by condensation and deposition or otherwise might cause an obstruction to its passage. For these purposes apparatus may be employed which is well known and which it is unnecessary to show in detail.

一般认为，冷却剂必须以足够的速率带走热量，来使得导体保持在所需的温度，并使一层所需厚度的包围导体的物质维持在冻结状态，持续抵消通过导体层和导体壁流入的热量以及由机械摩擦和电摩擦产生的热量。为了满足这些条件，冷却剂的取决于温度、密度、速度和比热的冷却能力，将借助于工程师熟悉的数据和公式来计算。空气通常适用于预期的用途；但是在特殊情况下，可以使用其它气体，如氢气，这样可以获得更高的冷却速度和更低的温度。显然，无论使用哪种气体，在进入空心导体或通道之前，都应被彻底干燥，并与所有因冷凝和沉积或其他原因可能阻碍其通过的气体分离。为了这些目的，可以使用众所周知的装置，没有必要详细展示。

Instead of being wasted at the distant station the cooling agent may be turned to some profitable use. Evidently in the industrial and commercial exploitation of my invention any kind of cooling agent capable of meeting the requirements may be conveyed from one to another station and there utilized for refrigeration, power, heating, lighting, sanitation, chemical processes, or any other propose to which it may lend itself, and thus the revenue of the plant may be increased.

冷却剂不会被浪费在远处的工作站，而是可以被转化为一些有益的用途。显然，在我的发明的工业开发和商业开发中，能够满足要求的任何种类的流体可以从一个站输送到另一个站，并且在那里用于制冷、供电、加热、照明、卫生、化工或任何其他它可以贡献自己的目的，并且因此工厂的收入可以增加。

As to the temperature of the conductor it will be determined by the nature of its use and considerations

of economy. For instance, if it be employed for the transmission of telegraphic messages, when the loss in electrical friction may be of no consequence, a very low temperature may not be required; but if it be used for transmitting large amounts of electrical energy, when the frictional waste may be a serious drawback, it will be desirable to keep it extremely cold. The attainment of this object will be facilitated by any provision for reducing as much as possible the flowing in of the heat from the surrounding medium. Clearly the lower the temperature of the conductor the smaller will be the loss in electrical friction; but, on the other hand, the colder the conductor the greater will be the influx of heat from the outside and the cost of the cooling agent. From such and similar considerations the temperature securing the highest economy will be ascertained.

至于导体的温度，将由它的使用性质和经济因素决定。例如，如果它被用来传输电报信息，当电摩擦中的损失可以是无关紧要时，可以不需要非常低的温度；但如果它被用来传输大量的电能，当摩擦浪费可能是一个严重的缺点时，就需要将它保持极冷。任何尽可能减少热量从周围介质流入的措施都有助于这个目的的实现。显然，导体的温度越低，电摩擦损失就越小；但是，另一方面，导体越冷，从外部流入的热量和冷却剂的成本就越大。从这样和类似的考虑中，可以确定获得最高经济性的温度。

Most frequently in the distribution of electricity for industrial purposes, as in my system of power transmission by alternate currents, more than one conductor will be required, and in such cases it may be convenient to circulate the cooling agent in a closed path formed by the conductors. A plan of this kind is illustrated in Fig. 3, in which C' and C^2 represent two hollow conductors embedded in a frozen mass underground and communicating, respectively, with the reservoirs R' and R^2 , which are connected by a reciprocating or other suitable pump P . Cooling coils or tubes T' T' and T^2 T^2 with regulating-valves v' v'' are employed, which are similar to and serve the same purpose as those shown in Fig. 1. Other features of similarity, though unnecessary, are illustrated to facilitate an understanding of the plan. A three-way valve V^2 is provided, which when placed with its lever l as indicated allows the cooling agent to enter through the tubes u' u^2 and pump P , thus filling the reservoirs R' R^2 and hollow conductors C' C^2 ; but when turned ninety degrees the valve shuts off the communication to the outside through the tube u' and establishes a connection between the reservoir R^2 and pump P through the tubes u^2 and u^3 , thus permitting the fluid to be circulated in the closed path $C' C^2 R^2 u^3 u^2 P R'$ by the action of the pump. Another valve V' of suitable construction may be used for regulating the flow of the cooling agent. The conductors C' C^2 are insulated from the reservoirs R' R^2 and from each other at the joints J' J^2 J^3 , and they are, furthermore, protected at the places where they enter and leave the ground by flanged bushings I' I' I^2 I^2 , of insulating material, which extend into the frozen mass in order to prevent the current from leaking, as above explained. Binding-posts B' B' and B^2 B^2 are provided for connecting the conductors to the circuit at each station.

最常见的是在工业配电中，如在我的交流电输电系统中，需要一个以上的导体，在这种情况下，可以方便地在导体形成的一条闭合路径中循环冷却剂。这种类型的一个方案如图 3 所示，其中 C' 和 C^2 表示埋在地下冻结物质中的两个空心导体，分别与蓄水池 R' 和 R^2 连通，这两个蓄水池通过往复泵或其他合适的泵 P 连接使用带有调节阀 v' v'' 的冷却盘管或管 T' T' 和 T^2 T^2 ，它们与图 1 中所示的盘管或管相似并用于相同的目的。其他相似的特征，虽然不是必要的，但是为了便于理解该方案而被展示。提供了一个三通阀 V^2 ，当其杠杆 l 如图所示放置时，允许冷却剂通过管 u' u^2 和泵 P 进入，从而填充容器 R' R^2 和空心导体 C' C^2 ；但是当该阀转动 90 度时，它切断了通过管 u' 与外部的连通，并通过管 u^2 和 u^3 建立了蓄水池 R^2 和

泵 P 之间的连接, 从而允许流体在泵的作用下在闭合路径 $C' C^2 R^2 u^3 u^2 P R'$ 中循环。具有合适结构的另一个阀 V' 可用于调节冷却剂的流量。导体 $C' C^2$ 与蓄水池 $R' R^2$ 绝缘, 并且在接头 $J' J^2 J^3$ 处彼此绝缘, 并且它们还在它们进入和离开地面的地方受到绝缘材料的凸缘套管 $I' I^1 I^2 I^3$ 的保护, 这些套管延伸到冻结体中, 以便防止电流泄漏, 如上所述。接线柱 $B' B'$ 和 $B^2 B^2$ 用于将导体连接到每个站的电路。

In laying the conductors, as $C' C^2$, whatever be their number, a trench will generally be dug and a trough, round or square, as T , of smaller dimensions than the trench placed in the same, the intervening space being packed with some material (designated by $M M M$) more or less impervious to heat, as sawdust, ashes, or the like. Next, the conductors will be put in position and temporarily supported in any convenient manner, and finally the trough will be filled with water or other substance W , which will be gradually frozen by circulating the cooling agent in the closed path, as before described. Usually the trench will not be level, but will follow the undulations of the ground, and this will make it necessary to subdivide the trough in sections or to effect the freezing of the substance filling it successively in parts. This being done and the conductors thus insulated and fixed, a layer of the same or similar material $M M M$ will be placed on the top and the whole covered with earth or pavement. The trough may be of metal, as sheet-iron, and in cases where the ground is used as return-circuit it may serve as a main or it may be of any kind of material more or less insulating. Figs. 4 and 5 illustrate in cross-section two such underground troughs T' and T'' , of metal sheet, with their adiathermanous enclosures, (designated M' and M'' , respectively,) each trough containing a single central hollow conductor, as C' and C'' . In the first case the insulation W' is supposed to be ice, obtained by freezing water preferably freed of air in order to exclude the formation of dangerous bubbles or cavities, while in the second case the frozen mass W'' is some aqueous or other substance or mixture highly insulating when in this condition.

在铺设导体 (如 $C' C^2$) 的过程中, 不管它们的数量, 通常会挖一个沟槽, 一个圆形或方形的槽 (如 T), 比沟槽更小的尺寸, 放置在该沟槽中, 中间的空间填充一些材料 (表示为 $M M M$) 或多或少不透热, 如锯屑、灰烬, 或类似的东西。接下来, 导体将被放置在适当的位置, 并以任何方便的方式被临时支撑, 最后, 沟槽将被水或其他物质 W 填充, 如前所述, 水或其他物质 W 将在闭合路径中循环的冷却剂逐渐冻结。通常, 沟槽不是水平的, 而是随着地面的起伏而起伏, 这就需要将沟槽分成几部分, 或者使连续填充其中的物质分几部分冻结。完成后, 导体因此被绝缘并被固定, 一层相同或相似材料 $M M M$ 将放置在顶部, 整体用土或路面覆盖。沟槽可以是金属的, 如铁皮, 在接地用作回路的情况下, 它可以作为一条干线, 或者它可以是任何种类的或多或少绝缘的材料。图 4 和图 5 展示了两个这样的金属板制成的地下沟槽 T' 和 T'' , 以及它们的绝热外壳 (分别表示为 M' 和 M''), 每个沟槽包含一个中心空心导体, 如 $C' C''$ 。在第一种情况下, 绝缘材料 W' 应该是通过冷冻首选不含空气的水而获得的冰, 以便排除危险的气泡或空穴的形成, 而在第二种情况下, 冷冻物质 W'' 是在这种条件下高度绝缘的一些含水物质或其它物质或混合物。

It should be stated that in many instances it may be practicable to dispense with a trough by resorting to simple expedients in the placing and insulating of the conductors. In fact, for some purposes it may be sufficient to simply cover the latter with a moist mass, as cement or other plastic material, which so long as it is kept at a very low temperature and frozen hard will afford adequate insulation.

应该指出的是, 在许多情况下, 通过在放置和绝缘导体时采取简单的权宜之计来省去沟槽是

可行的。事实上，对于某些目的来说，用潮湿的物质，如水泥或其他塑料材料，简单地覆盖后者就足够了，只要保持在非常低的温度和足够的冻结硬度将提供足够的绝缘。

Another typical way of carrying out my invention, to which reference has already been made, is shown in Fig. 6, which represents the cross-section of a trough, the same in other respects as those before shown, but containing instead of a hollow conductor any kind of pipe or conduit L. The cooling agent may be driven in any convenient manner through the pipe for the purpose of freezing the water or other substance filling the trough, thus insulating and fixing a number of conductors c c c. Such a plan may be particularly suitable in cities for insulating and fixing telegraph and telephone wires or the like. In such cases an exceedingly-low temperature of the cooling agent may not be required, and the insulation will be obtained at the expense of little power. The conduit L may, however, be used simultaneously for conveying and distributing any kind of fluid for which there is a demand through the district. Obviously two such conduits may be provided and used in a similar manner as the conductors C' C².

已经参考过的实施我的发明的另一种典型方式如图 6 所示，该图展示了沟槽的横截面，在其它方面与前面所示的相同，但是包含任何种类的管道或导管 L 而不是空心导体，冷却剂可以以任何方便的方式被驱动通过管道，目的是冻结填充沟槽的水或其他物质，从而绝缘和固定多个导体 c c c。这种方案可能特别适合于在城市中用来绝缘和固定电报和电话线等。在这种情况下，冷却剂可以不需要极低的温度，并且将以很少的功率为代价获得绝缘。然而，导管 L 可以同时用于输送和分配任何种类的流体，这在整个地区是有需求的。显然，可以提供两个这样的导管，并以与导体 C' C² 类似的方式使用。

It will often be desirable to place in the same trough a great number of wires or conductors serving for a variety of purposes. In such a case a plan may be adopted which is illustrated in Fig. 7, showing a trough similar to that in Fig. 6, with the conductors in cross-section. The cooling agent may be in this instance circulated, as in Fig. 3 or otherwise, through the two hollow conductors C³ and C⁴, which, if found advantageous, may be covered with a layer of cheap material m m, such as will improve their insulation, but not prevent the freezing or solidification of the surrounding substance W. The tubular conductors C' C², preferably of iron, may then serve to convey heavy currents for supplying light and power, while the small ones c' c' c', embedded in the ice or frozen mass, may be used for any other purposes.

通常希望在同一沟槽中放置大量用于各种目的的导线或导体。在这种情况下，可以采用图 7 所示的方案，图 7 展示了类似于图 6 的沟槽，其中导体处于横截面中。在这种情况下，冷却剂可以如图 3 或其他图，通过两个空心导体 C³ 和 C⁴ 循环，如果发现有利的话，可以用一层便宜的材料 m 覆盖，例如将改善它们的绝缘，但是不能防止周围物质 W 的冻结或凝固管状导体 C' C²，最好是铁的，可以用来传输大电流以提供光和电，而嵌入冰或冻结物质中的小导体 c' c' c' 可以用于任何其他目的。

While my invention contemplates, chiefly, the insulation of conductors employed in the transmission of electrical energy to a distance, it may be, obviously, otherwise usefully applied. In some instances, for example, it may be desirable to insulate and support a conductor in places as ordinarily done by means of glass or porcelain insulators. This may be effected in many ways by conveying a cooling agent either through the conductor or through an independent channel and freezing or solidifying any kind

of substance, thus enabling it to serve the purpose. Such an artificial insulating-support is illustrated in Fig. 8, in which a represents a vessel filled with water or other substance w, frozen by the agent circulating through the hollow conductor C", which is thus insulated and supported. To improve the insulation on the top, where it is most liable to give way, a layer of some substance w', as oil, may be used, and the conductor may be covered near the support with insulation i i, as shown, the same extending into the oil for reasons well understood.

虽然我的发明主要考虑了用于向远处传输电能的导体的绝缘,但显然它也可以有其他有用的应用。例如,在某些情况下,可能需要在某些地方绝缘和支撑一个导体,这通常是通过玻璃或陶瓷绝缘体来实现的。这可以通过多种方式实现,通过导体或通过一个独立的通道输送冷却剂,并冷冻或固化任何种类的物质,从而使其能够达到目的。这种人造绝缘支撑在图 8 中被展示出,其中 a 表示充满水或其他物质 w 的容器,被通过中空导体 C"循环的冷冻剂冻结,因此导体 C"被绝缘并被支撑。在顶部最容易塌陷,为了改善顶部的绝缘,可以使用一层某种物质 w',如油,并且导体可以在支架附近覆盖有绝缘 i i,如图所示,由于众所周知的原因,绝缘 i i 延伸到油中。

Another typical application of my invention is shown in Fig 9, in which P' and S' represent, respectively, the primary and secondary conductors, bare or insulated, of a transformers, which are wound on a core N and immersed in water or other substance W, containing a jar H and, as before stated, preferably freed of air by boiling or otherwise. The cooling agent is circulated in any convenient manner, as through the hollow primary P', for the purpose of freezing the substance W. Flanged bushings d d and oil-cups e e, extending into the frozen mass, illustrate suitable means for insulating the ends of the two conductors and preventing the leakage of the currents. A transformer, as described, is especially fitted for use with currents of high frequency, when a low temperature of the conductors is particularly desirable, and ice affords an exceptionally-effective insulation.

我的发明的另一个典型应用如图 9 所示,其中 P'和 S'分别代表变压器的初级导体和次级导体,裸露的或绝缘的,它们缠绕在磁芯 N 上并浸在水或其它物质 W 中,被容纳在一个罐 H 中,如前所述,最好通过煮沸或其它方法除去空气。为了冷冻物质 W,冷却剂以任何方便的方式循环,例如通过中空的初级 P'。延伸到冻结物质中的凸缘套管 d d 和油杯 e e 说明了用于绝缘两个导体的末端和防止电流泄漏的合适方法。当导体的低温是特别需要的,并且冰提供了特别有效的绝缘时,所描述的变压器特别适合用于高频电流。

It will be understood that my invention may be applied in many other ways, that the special means here described will be greatly varied according to the necessities, and that in each case many expedients will be adopted which are well known to engineers and electricians and on which it is unnecessary to dwell. However, it may be useful to state that in some instances a special provision will have to be made for effecting a uniform cooling of the substance surrounding the conductor throughout its length. Assuming in Fig. 1 the cooling agent to escape at the distant end freely into the atmosphere or into a reservoir maintained at low pressure, it will in passing through the hollow conductor C move with a velocity steadily increasing toward the end, expanding isothermally, or nearly so, and hence it will cause an approximately-uniform formation of ice along the conductor. In the plan illustrated in Fig. 3 a similar result will be in a measure attained, owing to the compensating effect of the hollow conductors C' and C², which may be still further enhanced by reversing periodically the direction of the flow in any convenient manner; but in many cases special arrangements will have to be employed to render the

cooling more or less uniform. For instance, referring to Figs. 4, 5, and 6, instead of a single channel two concentric channels L^1 and L^2 may be provided and the cooling agent passed through one and returned through the other, as indicated diagrammatically in Fig. 10. In this and any similar arrangement when the flow takes place in opposite directions the object aimed at will be more completely attained by reducing the temperature of the circulating cooling agent at the distant station, which may be done by simply expanding it into a large reservoir, as R^3 , or cooling it by means of a tube or coil T^3 , or otherwise. Evidently in the case illustrated the concentric tubes may be used as independent conductors, insulated from each other by the intervening fluid and from the ground by the frozen or solidified substance.

可以理解的是, 我的发明可以以许多其他方式应用, 这里描述的特定装置将根据需要而有很大变化, 并且在每种情况下, 将采用许多工程师和电工熟知的权宜之计, 并且没有必要详述。然而, 可能有必要说明, 在某些情况下, 必须采取特殊措施来实现导体周围物质在其整个长度上的均匀冷却。假设在图 1 中, 冷却剂在远端自由地逸出到大气中或进入维持在低压下的容器中, 它将在穿过中空导管 C 时以稳定增加的速度向端部移动, 等温膨胀, 或接近等温膨胀, 因此它将导致沿着导管近似均匀地形成冰。在图 3 所示的方案中, 由于中空导体 C^1 和 C^2 的抵消效果, 将在一定程度上获得类似的结果, 这可以通过以任何方便的方式周期性地反转流动方向来进一步增强; 但在许多情况下, 必须采用特殊布置来使冷却或多或少变得均匀。例如, 参考图 4、5 和 6, 而不是单个通道, 可以提供两个同心通道 L^1 和 L^2 , 冷却剂通过一个通道前进并通过另一个通道返回, 如图 10 中示意性地展示。在这种布置和任何类似的布置中, 当流动发生在相反的方向时, 通过降低在远处站的循环中的冷却剂的温度, 可以更完全地实现所要达到的目的, 这可以通过简单地将冷却剂膨胀到一个大的容器中来实现, 如 R^3 , 或者通过管或盘管 T^3 或其它方式来使冷却剂降温。显然, 在所示的情况下, 同心管 (同心的不同导管) 可以用作独立的导体, 通过介入流体彼此绝缘, 并通过被冻结或被固化的物质与地面绝缘。

Generally in the transmission of electrical energy in large amounts, when the quantity of heat to be carried off may be considerable, refrigerating apparatus thoroughly protected against the inflow of heat from the outside, as usual, will be employed at both the stations and, when the distance between them is very great, also at intermediate points, the machinery being advantageously operated by the currents transmitted or fluids conveyed. In such cases a fairly-uniform freezing of the insulating substance will be attained without difficulty by the compensating effect of the oppositely-circulating cooling agents. In large plants of this kind, when the saving of electrical energy in the transmission is the most important consideration or when the chief object is to reduce the cost of the mains by the employment of cheap metal, as iron, or otherwise, every effort will be made to maintain the conductors at the lowest possible temperature, and well-known refrigeration processes, as those based on the regenerative principle, may be resorted to, and in this and any other case the hollow conductors or channels instead of merely serving the purpose of conveying the cooling agent may themselves form active parts of the refrigerating apparatus.

通常, 在大量电能传输中, 当要带走的热量可能相当大时, 通常在两个站都将使用完全防止热量从外部流入的制冷设备, 并且当它们之间的距离非常大时, 在中间点也要如此, 机器由传输的电流或输送的冷却剂有优势地操作。在这种情况下, 通过反向循环冷却剂的抵消作用, 可以毫无困难地获得绝缘物质的相当均匀的冻结。在这种大型发电厂中, 当节约传输中的电能是最重要的考虑因素时, 或者当主要目的是通过使用廉价金属 (如铁或其他金属) 来降低电力网的成本时, 将尽一切努力将导体保持在尽可能低的温度, 并且可以采用众所周知的制

冷过程，如基于再生原理的制冷过程，并且在这种情况下和任何其它情况下，空心导体或通道不仅仅用于输送冷却剂，它们本身可以形成制冷设备的有效部件。

From the above description it will be readily seen that my invention forms a fundamental departure in principle from the established methods of insulating conductors employed in the industrial and commercial application of electricity. It aims, broadly, at obtaining insulation by the continuous expenditure of a moderate amount of energy instead of securing it only by virtue of an inherent physical property of the material used, as heretofore. More especially its object is to provide, when and wherever required, insulation of high quality, of any desired thickness and exceptionally cheap, and to enable the transmission of electrical energy under conditions of economy heretofore unattainable and at distances until now impracticable by dispensing with the necessity of using costly conductors and insulators.

从上面的描述中可以容易地看出，我的发明在原理上与工业和商业用电中所采用的绝缘导体的既定方法形成了根本的不同。概括地说，它的目的是通过持续消耗适量的能量来获得绝缘，而不是仅仅依靠迄今为止所用材料的固有物理特性来获得绝缘。更具体地说，其目的是在需要的时间和地方提供具有任何期望的厚度、并且特别便宜的高质量的绝缘，并且通过免除了使用昂贵的导体和绝缘体的必要性，能够在迄今为止无法实现的经济条件下和在迄今为止无法实现的距离上传输电能。

What I claim as my invention is—

1. The method of insulating electric conductors herein described which consists in imparting insulating properties to a material surrounding or contiguous to the said conductor by the continued action thereon of a cooling agent, as set forth.

1、在此描述的使电导体绝缘的方法，包括通过冷却剂在其上的持续作用，赋予所述导体周围或邻近的材料绝缘性能，如上所述。

2. The method of insulating electric conductors herein described which consists in reducing to and maintaining in a frozen or solidified condition the material surrounding or contiguous to the said conductor by the action thereon of a cooling agent maintained in circulation through one or more channels as set forth.

2、在此描述的使电导体绝缘的方法，包括通过气态冷却剂在其上的作用将所述导体周围或附近的材料减少并保持在冻结或凝固状态，所述冷却剂通过一个或多个通道维持循环，如上所述。

3. The method of insulating electric conductors herein described which consists in surrounding or supporting the conductor by material which acquires insulating properties when in a frozen or solidified state, and maintaining the material in such a state by the circulation through one or more channels extending through it of a cooling agent, as set forth.

3、在此描述的使电导体绝缘的方法，包括用在一个冷冻固化状态下获得绝缘性能的材料来包围或支撑导体，并通过冷却剂在一个或多个贯穿该材料的通道中的循环将材料保持在这种状态，如上所述。

4. The method of insulating an electric conductor which consists in surrounding or supporting said conductor by a material which acquires insulating properties when frozen or solidified, and maintaining the material in such state by passing a cooling agent continuously through a channel in said conductor, as set forth.

4、一种使电导体绝缘的方法，包括用一种在冻结或固化时获得绝缘性能的材料来包围或支撑所述导体，并通过使冷却剂持续通过所述导体中的通道来保持该材料处于这种状态，如前所述。

5. The method of insulating electric conductors, which consists in surrounding or supporting the said conductors by a material which acquires insulating properties when in a frozen or solidified state, and maintaining the material in such state by the continued application thereto of a cooling agent, as set forth.

5、一种使电导体绝缘的方法，该方法包括用一种在冻结或凝固状态下具有绝缘性能的材料来包围或支撑所述导体，并通过向该材料持续应用冷却剂来保持该材料处于上述状态。

6. The method of insulating conductors herein set forth which consists in surrounding or supporting the conductors by a material which acquires insulating properties when in a frozen or solidified state, and maintaining the material in such state by the circulation of a cooling agent through a circuit of pipes or tubes extending through the said material as set forth.

6、在此阐述的绝缘导体的方法，包括用在冻结或固化状态下获得绝缘性能的材料来包围或支撑该导体，并通过冷却剂在延伸穿过所述材料的管道或导管回路中的循环将材料保持在这种状态。

7. The method of insulating electric conductors which consists in laying or supporting the conductors in a trough or conduit filling the trough with a material which acquires insulating properties when frozen or solidified, and then causing a cooling agent to circulate through one or more channels extending through the material in the trough so as to freeze or solidify the material, as set forth.

7、绝缘电导体的方法，包括将导体放置或支撑在沟槽或导管中，用冷冻或固化时获得绝缘性能的材料填充沟槽或导管，然后使冷却剂循环通过一个或多个延伸穿过沟槽中材料的通道，以便冷冻或固化材料，如上所述。

NIKOLA TESLA.

尼古拉·特斯拉

Witnesses:

PARKER W. PAGE,

M. LAWSON DYER.

见证人:

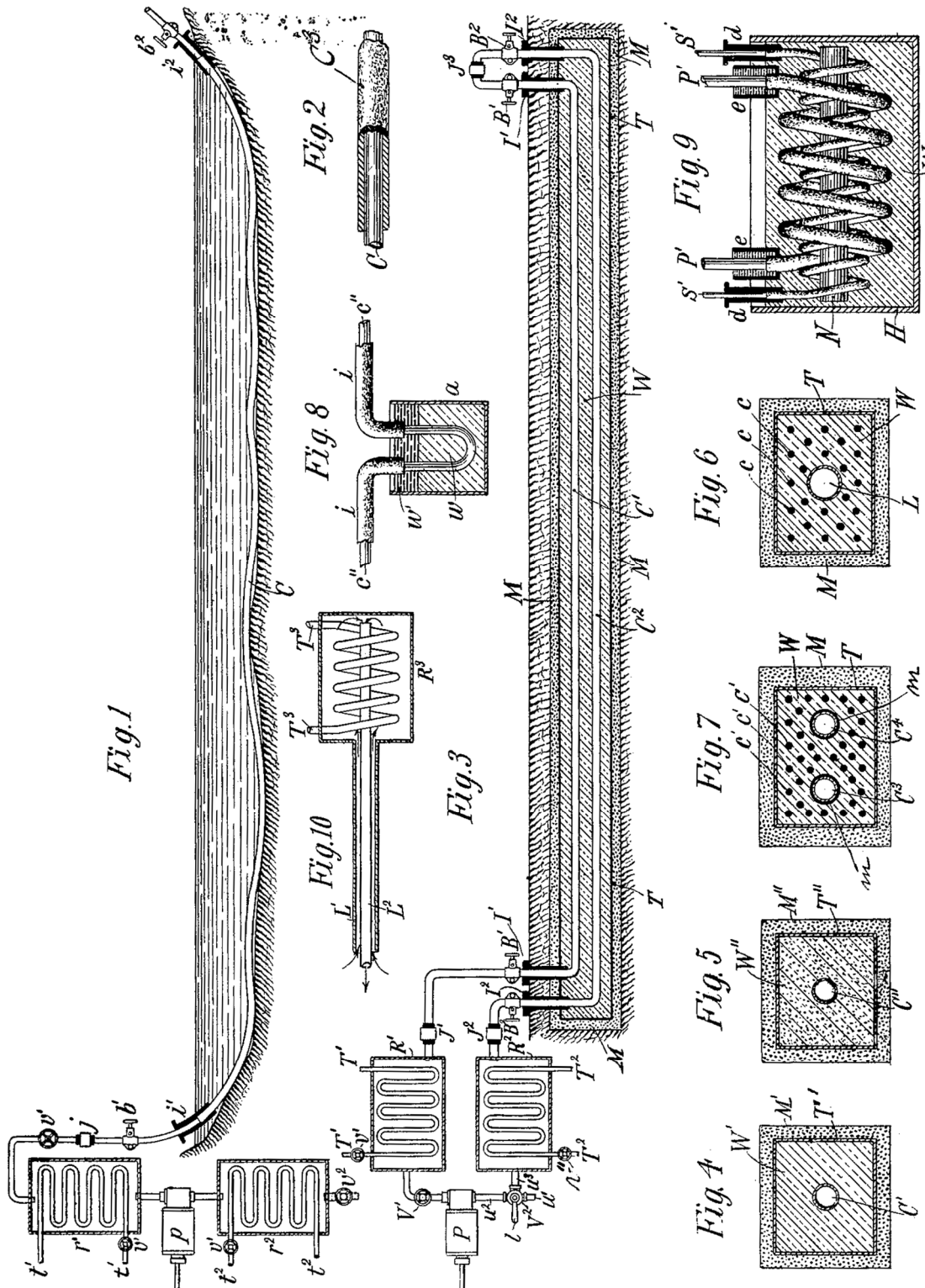
帕克·W·佩奇、M·劳森·戴尔。

N. TESLA.

METHOD OF INSULATING ELECTRIC CONDUCTORS.

(Application filed June 15, 1900.)

(No Model.)



Witnesses:

Raphaël Ketter
C. D. Morrill,

Nikola Tesla, Inventor

by Kerr, Page & Cooper,
Attys

MEANS FOR GENERATING ELECTRIC CURRENTS.

用于产生电流的工具

NIKOLA TESLA, OF NEW YORK, N. Y.
纽约州纽约市的尼古拉·特斯拉

SPECIFICATION forming part of Letters Patent No. 514,168, dated February 6, 1894.

Application filed August 2, 1893. Serial No. 482,194. (No model.)

该说明书形成了颁发于 1894 年 2 月 6 日编号为 514,168 的专利证书的一部分。

申请于 1893 年 8 月 2 日提交。序列号为 482,194。(没有模型)

To all whom it may concern:

致所有相关人士:

Be it known that I, NIKOLA TESLA, a citizen of the United States, residing at New York, in the county and State of New York, have invented certain new and useful Improvements in Means for Generating Electric Currents, of which the following is a specification, reference being had to the drawings accompanying and forming a part of the same.

众所周知，我、尼古拉·特斯拉、一位美国公民，现在居住在纽约州纽约郡纽约市，在用于产生电流的工具方面已经发明了某种新的和有用的改进，以下是该发明一个说明书，必须参考随附的图纸，它已经形成了该说明的一部分。

The invention, subject of my present application, is an improvement applicable more especially to the method or system of generating and utilizing electrical energy, heretofore discovered by me, and more fully set forth in Letters Patent No. 454,622, of June 23, 1891, and No. 462,418, of November 3, 1891, and which involves the maintenance of an intermittent or oscillatory discharge of a condenser or circuit of suitable capacity into a working circuit containing translating devices. In systems of this character when the high frequency of the currents employed is due to the action of a disruptive or intermittent discharge across an air gap or break at some point of the circuit, I have found it to be of advantage not only to break up or destroy the least tendency to continuity of the arc or discharge, but also to control the period of the re-establishment of the same, and from investigations made by me with this object in view I have found that greatly improved results are secured by causing the discharge to take place in and through an insulating liquid, such as oil, and instead of allowing the terminal points of the break to remain at a uniform distance from each other, to vary such distance by bringing them periodically in actual contact or sufficiently near to establish the discharge and then separating them, or what is the equivalent of this, throwing in and out of the gap or break a conducting bridge at predetermined intervals. To obtain the best results, moreover, I find it essential to maintain at the point of discharge a flow of the insulating medium, or, in general, such a circulation of the same as will constantly operate to cut off or brake up the discharge as fast as it is established. The accomplishment of this latter result

involves the employment of some mechanism for maintaining the flow or circulation of the insulating medium past the points of discharge, and I take advantage of the presence of such mechanism to accomplish a further and beneficial result which is the maintenance of a flow or circulation of the insulating liquid in which I immerse the converter coils used for raising the potential of the current, and also the condenser plates when such are required and used. By this means the insulating liquid surrounding the said coils and plates may be prevented from heating, either by its circulation alone or by the application to it while in motion of a cooling medium, and its requisite qualities preserved for an indefinite time.

本发明作为我的本申请的主题，是一种改进，尤其适用于产生和利用电能的方法或系统，迄今为止该方法或系统是由我发现的，并在 1891 年 6 月 23 日的第 454,622 号专利证书中和 1891 年 11 月 3 日的第 462,418 号专利证书中都有更全面的阐述，该专利涉及维持一个电容器或具有适当容量的电路的间歇放电或振荡放电，该放电被释放到包含转换装置的一个工作电路中。在这种特征的系统，当所采用的高频电流是由于跨越电路的某一点处的空气间隙或断路的破坏性放电或间歇性放电的作用时，我发现它不仅有利于中断或破坏电弧或放电的最小连续性的趋势，而且有利于控制电弧或放电的重新建立的周期，根据我针对该目的所做的研究，我发现通过使放电发生在绝缘液体(例如油)中并使放电通过绝缘液体，而不是允许断开的端点彼此保持一致的距离，通过使它们周期性地实际接触或足够接近以建立放电，然后将它们分开，或者以预定的时间间隔插入和拔出间隙或断路来等同于此，以改变这种放电距离，可以确保大大改善的结果。此外，为了获得最好的结果，我发现有必要在放电点保持绝缘介质的流动，或者，总的来说，这样的介质循环将像放电的建立那样快地不断地切断或制动放电。后一种结果的实现包括采用一些机械装置来维持绝缘介质经过放电点的流动或循环，并且我利用这种机械装置来实现进一步的和有益的结果，即维持绝缘液体的流动或循环，我将用于提高电流电势的转换器线圈浸入这种绝缘液体中，并且当需要和使用电容器极板时，我也将其浸入这种液体中。通过这种方式，可以防止围绕所述线圈和极板的绝缘液体被加热，或者通过绝缘液体单独循环或者通过在冷却介质运动时对绝缘液体施加循环，并且绝缘液体的必要品质可以无限期地保持。

Broadly considered the plan contemplated is entirely independent of the special means for carrying it into execution, but in illustration of the preferred manner in which the invention is or may be carried out, I now refer to the drawings which are hereto annexed.

大体上考虑，所设想的方案完全独立于用于实施它的特殊工具，但是为了说明本发明被实施或可能被实施的优选方式，我现在参考这些文件后的附图。

Figure 1 is a diagram of the system and devices employed by me. Fig. 2 is a sectional view of a detail of mechanism.

图 1 是我使用的系统和设备的一张示意图。图 2 是详细的机械装置的一张截面图。

G represents an electrical generator, as for instance, an ordinary alternator, in the circuit of which is the primary P of a transformer, of which S represents the secondary, which is usually of much longer and finer wire than the primary. To the secondary circuit, if it have not of itself sufficient capacity for the purpose herein contemplated, are connected the plates of a condenser C, and at any point in said circuit is a break or gap at which occurs the disruptive discharge. In a portion of the secondary circuit,

preferably in series with the condenser, as shown in the drawings, is a primary coil P' with which is associated a secondary S', which later constitutes the ultimate source of currents for a working circuit D in which or with which are connected translating devices E. Under the conditions assumed it will be understood that by the oscillation or change caused by the action of the discharge, the condenser is charged and discharged setting up in the primary P' an electrical disturbance of enormous frequency, as has been explained in my patent referred to, and as is now well understood. Instead of employing two terminals at a fixed distance, however, for the gap across which the discharge takes place, I vary the distance between them, or what is practically the same thing, I interpose between said terminals a conductor or a series of conductors successively by means of which the effective distance or length of the path of discharge is or may be varied at will. This I accomplish in the following manner:

G 代表一个发电机,例如,一个普通的交流发电机,在它的电路中的是一个变压器的初级 P, S 代表该变压器的次级,次级通常比初级长得多,细得多。如果次级电路本身没有足够的电容量用于这里所预期的目的,则次级电路连接有一个电容器 C 的极板,并且在所述电路中的任何点都可以有发生破坏性放电的一个断路或间隙。如图所示,在次级电路的一部分中,优选地与该电容器串联的是初级线圈 P',次级线圈 S'与初级线圈 P'相关联,次级线圈 S'随后构成工作电路 D 的最终电源,在工作电路 D 中有转换装置 E 或工作电路 D 与转换装置 E 相连。在假设的条件下,可以理解的是,通过放电动作引起的振荡或变化,电容器被充电和放电,该放电在初级 P'中产生巨大频率的电扰动,这在我的参考专利中已经解释过,现在也能很好理解。然而,对于发生放电的间隙,不是采用固定距离的两个终端,而是改变它们之间的距离,或者实际上是相同的事情,我在所述终端之间相继插入一个导体或一系列导体,通过这种方式,放电路径的有效距离或长度可以任意改变。这一点我是通过以下方式实现的:

A is a pipe or tube that leads into a tank B. To the end of this tube is secured an extension F of insulating material and the two terminals G' G' are caused to project through the sides of the same, as indicated in Fig. 2. Within the extension I secure two cross-bars H which afford bearings for the spindle of a small metallic turbine I, the blades of which, as the turbine revolves, bridge the space between the two terminals, nearly or quite touching the terminals in their movement. If now the tank B be filled with oil and the latter is drawn off or permitted to flow off through the tube A, the turbine will be rotated by the flow, the rate of rotation being dependent upon the rate of flow. By this means the arc or discharge is periodically established through a flow of oil, which secures in the most satisfactory manner the conditions best adapted for practical results.

A 是一根通向油箱 B 的管道。如图 2 所示,绝缘材料的一个延伸部分 F 固定在该管道的端部,并且两个终端 G' G'穿过该管道的侧面并伸出。在延伸部分中我固定有两个横杆 H,横杆 H 为小型金属涡轮 I 的心轴提供轴承,当涡轮旋转时,涡轮的叶片桥接两个终端之间的空间,在叶片运动时几乎或完全接触两个终端。如果现在油箱 B 充满了油,并且油通过管道 A 被抽出或被允许流出,涡轮将通过油的流动而旋转,旋转的速率取决于流动的速率。通过这种方式,电弧或放电通过油的流动被周期性地建立,从而以最令人满意的方式确保最适合实际结果的条件。

The further objects of the invention are secured by placing the transformer P' S' in the body of oil in the tank B, and the condenser in a closed receptacle L. Then in order to maintain a circulation of the oil and to provide for the requisite flow which rotates the turbine, I connect the tank B with the condenser box L by means of the pipe A. I also run a pipe M from the box L to a small rotary pump

N, and another pipe O from the latter back to the tank B.

通过将变压器 P' S' 放置在油箱 B 中的油体内，并将电容器放置在封闭的容器 L 中，实现了本发明的其他目的。然后，为了保持油的循环并提供旋转涡轮所需的流量，我利用管道 A 将油箱 B 与电容器箱 L 连接起来。我还把一根管道 M 从箱子 L 通到一个小型旋转泵 N，另一根管道 O 从后者回到油箱 B。

When necessary or desirable I may insert in the pipe O a coil R, which is contained in a jacket T through which a cooling medium is passed.

当需要或可取时，我可以在管道 O 中插入一个线圈 R，线圈 R 被包含在冷却介质通过的夹套 T 中。

The flow of oil is regulated by the speed at which the pump N is driven, and by this means the period of re-establishment of the arc is controlled.

油的流量由驱动泵 N 的速度来调节，以这种方式来控制电弧的重建周期。

Having now described my invention and the best means of which I am aware in which the same is or may be carried into effect, what I claim is—

现在已经描述了我的发明和我所知道的实现或可能实现该发明的最佳方法，我主张的是—

1. In an electric system of the kind described, the combination with the points or terminals between which occurs the intermittent or oscillating discharge of means for maintaining between said points and in the path of the discharge of a flow of insulating liquid, as set forth.

1、在所述类型的一个电气系统中，存在一个组合，它包括：相互之间发生间歇放电或振荡放电的点或终端；以及用于在所述点和绝缘液体流的放电路径之间维持放电的工具，如上所述。

2. In an electrical system of the kind described, the combination with a transformer, and the points or terminals between which occurs the intermittent or oscillating discharge, of a body of insulating liquid surrounding the same, and means for maintaining a flow or circulation of the same, as set forth.

2、在所述类型的一个电气系统中，存在一个组合，它包括：一个变压器；相互之间发生间歇放电或振荡放电的点或终端；在该点或终端周围的绝缘液体；以及用于绝缘液体流动或循环的装置，如上所述。

3. In an electrical system of the kind described, the combination with a transformer and the points or terminals between which occurs the intermittent or oscillating discharge, of receptacles enclosing the same and containing oil and means for maintaining a flow of oil through said receptacles and around the devices therein, as set forth.

3、在所述类型的一个电气系统中，存在一个组合，它包括：一个变压器；相互之间发生间

歇放电或振荡放电的点或终端；封闭该点或终端并容纳油的容器；以及用于保持油流过所述容器并围绕其中的装置的工具，如上所述。

4. In an electrical system of the kind described, the combination with the points or terminals between which occurs the intermittent or oscillating discharge, of a means for maintaining a flow of insulating liquid between the discharge points, and means for varying the length of the path of discharge through such fluid, dependent for operation upon the flow of the same, as set forth.

4、在所述类型的一个电气系统中，存在一个组合，它包括：相互之间发生间歇放电或振荡放电的点或终端；在放电点之间维持绝缘液体流动的工具；通过这种液体改变放电长度和路径的工具，取决于液体流动的操作，如上所述。

5. The combination with discharge points immersed in oil, of means for periodically varying the length of the path of discharge between them, as described.

5、将浸入油中的放电点与周期性改变它们之间放电路径长度的工具的组合，如上所述。

6. The combination with discharge points immersed in oil, of a conductor adapted to periodically bridge the space between such points, as set forth.

6、浸入油中的放电点与适于周期性地桥接这些点之间的空间的导体的组合，如上所述。

7. The combination with discharge points immersed in oil, means for causing a flow of the oil between said points and a metallic turbine mounted between the points and adapted by the rotation produced by the flowing oil to bridge with its vanes or blades the space between the said points.

7、存在一个组合，它包括：浸入油中的放电点；用于使油在所述点之间流动的装置；安装在所述点之间的金属涡轮，该金属涡轮适于通过流动的油产生的旋转，以其叶片或桨叶桥接所述点之间的空间，如上所述。

NIKOLA TESLA.

尼古拉·特斯拉

Witnesses:

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见证人:

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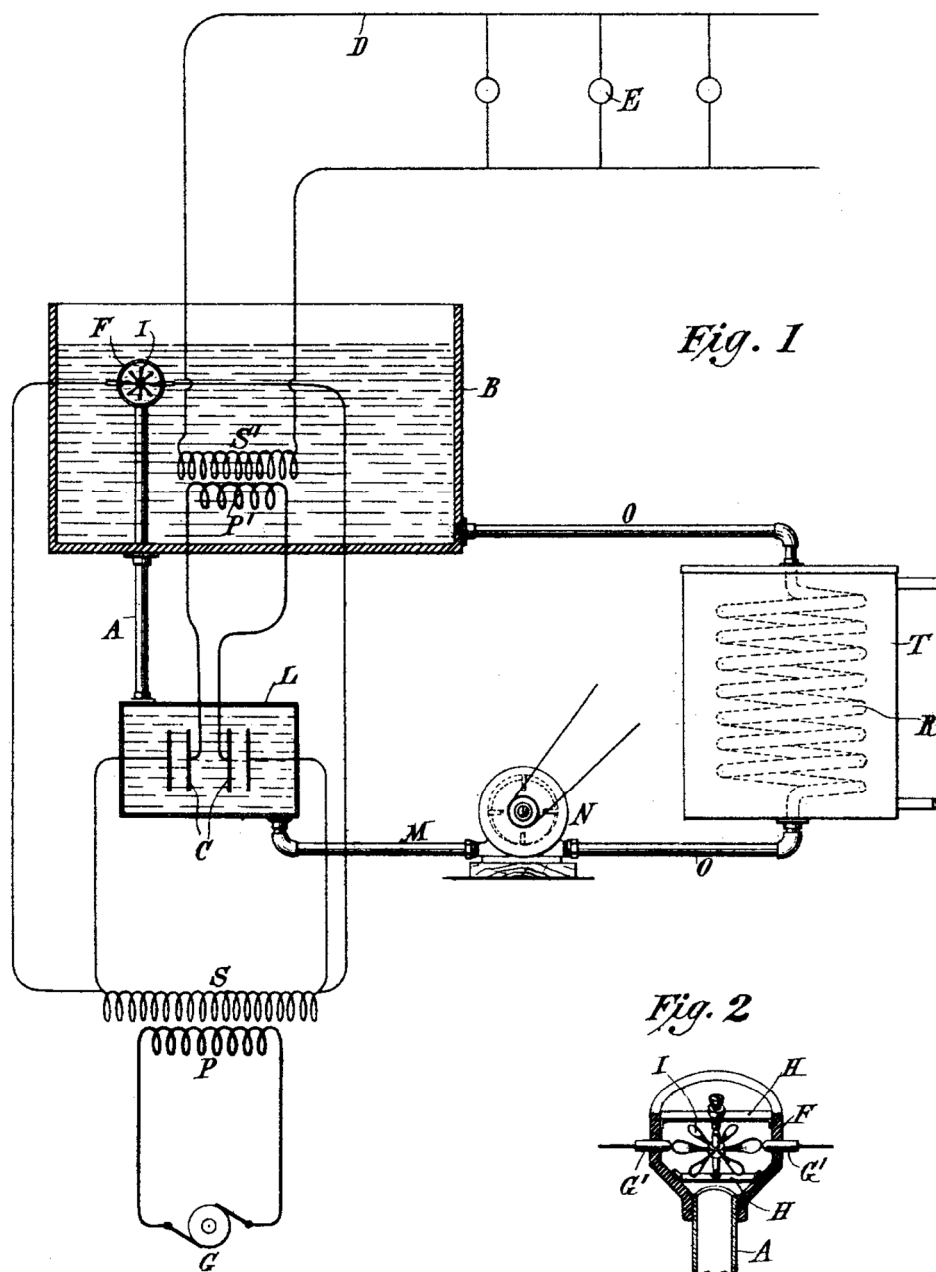
(No Model.)

N. TESLA.

MEANS FOR GENERATING ELECTRIC CURRENTS.

No. 514,168.

Patented Feb. 6, 1894.



Witnesses
Raphael Netter
James W. Cotton

Inventor
Nikola Tesla
By his Attorneys
Duncan & Page

APPARATUS FOR PRODUCING ELECTRIC CURRENTS OF HIGH FREQUENCY AND POTENTIAL. 用于产生高频高电位电流的装置

NIKOLA TESLA, OF NEW YORK, N. Y.

纽约州纽约市的尼古拉·特斯拉

SPECIFICATION forming part of Letters Patent No. 568,176, dated September 22, 1896.

Application filed April 22, 1896. Serial No. 588,534. (No model.)

该说明书形成了颁发于 1896 年 9 月 22 日编号为 568,176 的专利证书的一部分。

原始申请于 1896 年 4 月 22 日提交，序列号 588,534。（没有模型）

To all whom it may concern:

致所有相关人士：

Be it known that I, NIKOLA TESLA, a citizen of the United States, residing at New York, in the county and State of New York, have invented certain new and useful Improvements in Apparatus for Production of Electric Currents of High Frequency and Potential, of which the following is a specification, reference being had to the drawings accompanying and forming a part of the same.

众所周知，我、尼古拉·特斯拉，一位美国公民，居住在纽约州纽约郡纽约市，在用来产生高频高电位电流的装置方面已经发明了某些新的和有用的改进，以下是该发明一个说明书，必须参考随附的图纸，它已形成了该说明书的一部分。

The invention which forms the subject of my present application is embodied in an improvement on an electrical apparatus invented by me and described in prior Letters Patent, notably in United States Patents No. 462,418, dated November 3, 1891, and No. 454,622, dated June 23, 1891. This apparatus was devised for the purpose of converting and supplying electrical energy in a form suited for the production of certain novel electrical phenomena which require currents of higher frequency and potential than can readily or even possibly be developed by generators of the ordinary types or by such mechanical appliances as were heretofore known. The apparatus, as a whole, involves means for utilizing the intermittent or oscillating discharge of the accumulated electrical energy of a condenser or a circuit possessing capacity in what may be designated the “working” circuit, or that which contains the translating devices or those which are operated by such currents.

构成本申请主题的发明体现在由我发明的并在以前的专利证书中描述的电气设备的一个改进中，特别是分别在 1891 年 11 月 3 日和同年 6 月 23 日的被授予的美国专利第 462,418 号和第 454,622 号。这种装置是为了转换和供应电能而设计的，其形式适合于产生某些新颖的电现象，这种电现象需要的电流要比普通类型的发电机或迄今已知的这类机械装置容易地或甚

至可能地产生的电流具有更高的频率和更高的电势。作为一个整体，涉及到对电容器或具有容量的电路的累积电能的间歇或振荡放电进行利用的装置，该电容器或电路被指派到“工作”电路中，或包含转换装置的电路或那些由这种电流操作电路。

The object of my present improvements is to provide a simple, compact, and effective apparatus for producing these effects, but adapted more particularly for direct application to and use with existing circuits carrying direct currents, such as the ordinary municipal incandescent-lighting circuits. The way in which I accomplish this, so as to meet the requirements of practical and economical operation under the conditions present, will be understood from a general description of the apparatus which I have devised. In any given circuit, which for present purposes may be considered as conveying direct currents or those of substantially the character of direct or continuous currents and which for general purposes of illustration may be assumed to be a branch or derived circuit across the mains from any ordinary source, I interpose a device or devices in the nature of a choking-coil in order to give to the circuit a high self-induction. I also provide a circuit-controller of any proper character that may be operated to make and break said circuit. Around the break or point of interruption I place a condenser or condensers to store the energy of the discharge-current, and in a local circuit and in series with such condenser I place the primary of a transformer, the secondary of which then becomes the source of the currents of high frequency. It will be apparent from a consideration of the conditions involved that were the condenser to be directly charged by the current from the source and then discharged into the working circuit a very large capacity would ordinarily be required, but by the above arrangement the current of high electromotive force which is induced at each break of the main circuit furnishes the proper current for charging the condenser, which may therefore be small and inexpensive. Moreover, it will be observed that since the self-induction of the circuit through which the condenser discharges, as well as the capacity of the condenser itself, may be given practically any desired value, the frequency of the discharge-current may be adjusted at will.

我的当前改进的目的是提供一种简单、紧凑和有效的装置用于产生这些效果，但更特别适用于直接应用和与现有的载有直流电的电路一起使用，例如普通的市政白炽灯照明电路。从我所设计的设备的一般描述中，将会理解我实现这一点的方式，以便满足在当前条件下实际和经济操作的要求。在任何给定的电路中，为了本发明的目的，该电路可以被认为输送直流电流或那些基本上具有直流或恒向电流特性的电路，并且为了说明的一般目的，该电路可以被假设为是连接在来自任何普通电流源的两条干线上的一条分支电路或间接电路（这种电路有包含电感），我插入了一个或多个具有扼流线圈性质的装置，以便给予该电路一个高的自感。我还提供了一种具有任何适当特征的电路控制器，可以被操作来接通和断开所述电路。在断点或中断点周围，我放置一个或多个电容器来存储放电电流的能量，在一个局部电路中和与这样的电容器串联的电路中，我放置一个变压器的初级，它的次级成为高频电流的来源。从所涉及的条件来看，显而易见的是，电容器由来自电源的电流直接充电，然后放电到工作电路中，该电路通常需要非常大的容量，但是通过上述布置，在干线的每次断开时感应生成的高电动势电流提供了用于对电容器充电的适当电流，因此电容器可以是小的和便宜的。此外，可以观察到，由于电容器放电所通过的电路的自感以及电容器本身的容量实际上可以给定任何期望值，所以放电电流的频率可以随意调节。

The object sought in this invention may be realized by specifically different arrangements of apparatus, but in the drawings hereto annexed I have illustrated forms which are typical of the best and most practicable means for carrying out the invention of which I am at present aware.

本发明所寻求的目的可以通过具体不同的装置布置来实现，但是在本文所附的附图中，我已经展示出用于实施我目前所知的发明的最佳和最可行的典型形式。

Figure 1 is a diagrammatic illustration of the apparatus, and Fig. 2 a modification of the same.

图 1 是该装置的一个示意图，图 2 是该装置的改进型。

Referring to Fig. 1, A designates any source of direct current. In any branch of the circuit from said source, such, for example, as would be formed by the conductors A" A" from the mains A' and the conductors K K, are placed self-induction or choking coils B B and a circuit-controller C. This latter may be an ordinary metallic disk or cylinder with teeth or separated segments D D E E, of which one or more pairs, as E E, diametrically opposite, are integral or in electrical contact with the body of the cylinder, so that when the controller is in the position in which the two brushes F F bear upon two of said segments E E the circuit through the choking-coils B will be closed. The segments D D are insulated, and while shown in the drawings as of substantially the same length of arc as the segments E E this latter relation may be varied at will to regulate the periods of charging and discharging.

参照图 1，A 表示任何直流电源。在来自所述电源的电路的任何分支中，例如由来自干线 A' 的导体 A" A" 和导体 K K 形成的分支中，放置了自感或扼流线圈 B B 和一个电路控制器 C。后者可以是一个普通的金属盘或圆柱，带有齿或分段 D D E E，其中一对或多对，如 E E 在直径上是相对的，与圆柱主体是一体的或电接触，因此当控制器处于两个电刷 F F 倚靠在两个所述分段 E E 上的位置时，通过扼流线圈 B 的电路将闭合。分段 D D 是被绝缘的，虽然在图中显示为与分段 E E 大致相同的弧长，但后一种关系可以随意改变，以调节充电和放电的周期。

The controller C is designed to be rotated by any proper device, such, for example, as an electromagnetic motor, as shown in Fig. 2, receiving current either from the main source or elsewhere. Around the controller C, or in general in parallel therewith, is a condenser H, and in series with the latter the primary K of a transformer, the secondary L of which constitutes the source of the currents of high frequency which may be applied to many useful purposes, as for electric illumination, the operation of Crooke's tubes, or the production of high vacua.

控制器 C 被设计成由任何合适的装置旋转，例如，如图 2 所示的电磁电动机，从干线电源或其它地方接收电流。在控制器 C 的周围，或者通常与其并联的是电容器 H，并且与后者串联的是一个变压器的初级 K，其次级 L 构成高频电流的来源，该高频电流可以应用于许多有用的目的，如用于电照明、克鲁克兹管的运行或者高真空的产生。

L' indicates the circuit from the secondary, which may be regarded as the working circuit.

L' 表示来自次级的电路，该次级可被视为工作电路。

A more convenient and simplified arrangement of the apparatus is shown in Fig. 2. In this case the small motor G, which drives the controller, has its field-coils in derivation to the main circuit, and the controller C and condenser H are in parallel in the field-circuit between the two coils. In such case the field-coils M take the place of the choking-coils B. In this arrangement, and in fact generally, it is

preferable to use two condensers or a condenser in two parts and to arrange the primary coil of the transformer between them. The interruptions of the field-circuit of the motor should be so rapid as to permit only a partial demagnetization of the cores. These latter, however, should in this specific arrangement be laminated.

图 2 展示了该设备的更方便和简化了的布置。在这种情况下，驱动控制器的小电机 G 的励磁线圈连接到干线，控制器 C 和电容器 H 并联在两个线圈之间的励磁电路中。在这种情况下，励磁线圈 M 代替了两个扼流线圈 B。在这种布置中，并且实际上通常首选使用两个电容器或者将一个电容器分成两部分使用，并且将变压器的初级线圈布置在它们之间。电动机磁场电路的中断应如此之快，以允许铁芯仅部分退磁。然而，在这种特定的布置中，后者应该是叠片的。

The apparatus, as will now be seen, comprises, as essential elements, choking-coils, a circuit-controller, means for rotating the same, a condenser, and a transformer. These elements may be mechanically associated in any convenient and compact form, but so far as their general arrangement and relations are concerned I prefer the relative disposition illustrated, mainly because, by reason of their symmetrical arrangement in the circuit, the liability of injury to the insulation of any of the devices is reduced to a minimum.

如现在将看到的，该设备包括作为基本组件的两个扼流线圈、一个电路控制器、用于旋转该电路控制器的装置方法、一个电容器和一个变压器。这些组件可以以任何方便和紧凑的形式进行机械连接，但就其总体布置和关系而言，我更喜欢所示的相对布置，主要是因为，由于它们在电路中的对称布置，对任何设备的绝缘造成伤害的可能性降低到最小。

I do not mean to imply by the terms employed in describing my improvements that I limit myself to the use of the precise devices commonly designated by such terms. For instance, the choking-coil as a distinctive device may be wholly dispensed with, provided the circuit in which it must otherwise be placed have a sufficiently high self-induction produced in other ways. So, too, the necessity of a condenser, strictly speaking, is avoided when the circuit itself possesses sufficient capacity to accomplish the desired result.

我并不打算利用在描述我的改进时所使用的术语来暗示我将自己限制在使用这些术语通常指定的精密设备上。例如，如果必须放置扼流线圈的电路具有以其他方式产生的足够高的自感，那么作为独特装置的扼流线圈可以完全省去。因此，严格地说，当电路本身具有足够的容量来达到预期的结果时，就不需要电容器了。

Having now described my invention and the manner in which the same is or may be carried into practical effect, what I claim is—

现在已经描述了我的发明以及将其付诸实践或可能付诸实践的方式，我主张的是——

1. The apparatus herein described for converting direct currents into currents of high frequency, comprising in combination a circuit of high self-induction, a circuit-controller adapted to make and break such circuit, a condenser into which the said circuit discharges when interrupted, and a transformer through the primary of which the condenser discharges as set forth.

1、这里描述的用于将直流电转换成高频电流的装置，包括形成组合的一个高自感电路；适于接通和断开这种电路的一个电路控制器；当中断时所述电路向其放电的一个电容器；以及一个变压器，电容器通过该变压器的初级线圈放电，如上所述。

2. The combination of a source of direct current and a circuit therefrom, choking-coils in said circuit, means for making and breaking the circuit through said coils, a condenser around the point of interruption in the said circuit and a transformer having its primary in circuit with the condenser as set forth.

2、一个组合，它包括一个直流电源和来自该电源的一个电路；所述电路中的扼流线圈；用于接通和断开通过所述扼流线圈的电路的装置方法；在所述电路中的中断点周围的一个电容器；以及一个变压器，其初级与该电容器在一个电路中，如上所述。

3. The combination with a circuit of high self-induction and means for making and breaking the same, of a condenser around the point of interruption in the said circuit, and a transformer the primary of which is in the condenser-circuit as described.

3、一个组合，它包括一个高自感电路以及用于接通和断开该电路的装置方法；在所述电路的中断点周围的一个电容器；以及一个变压器，其初级在所述的电容器电路中。

4. The combination with a circuit of direct current and having a high self-induction, of a circuit-controller for making and breaking said circuit, a motor for driving the controller, a condenser in a circuit connected with the first around the point of interruption therein, and a transformer the primary of which is in circuit with the condenser as set forth.

4、一个组合，它包括一个用于接通和断开所述电路的一个电路控制器；用于驱动控制器的一个电动机；在电路中围绕其中的中断点与电路控制器连接的一个电容器；以及一个变压器，其初级在电路中与该电容器相连，如上所述。

5. The combination with a circuit of direct current, a controller for making and breaking the same, a motor having its field-magnets in said circuit and driving the said controller, a condenser connected with the circuit around the point of interruption therein and a transformer of the primary of which is in circuit with the condenser as set forth.

5、一个组合，它包括一个直流电路；一个用于接通和断开该直流电路的控制器；在所述电路中具有其场磁体并驱动所述控制器的电动机；在该电路中的中断点周围与该电路连接的一个电容器；以及一个变压器，其初级线圈与电容器在一个电路中，如上所述。

NIKOLA TESLA.

尼古拉·特斯拉

Witnesses:

EDWIN B. HOPKINSON,

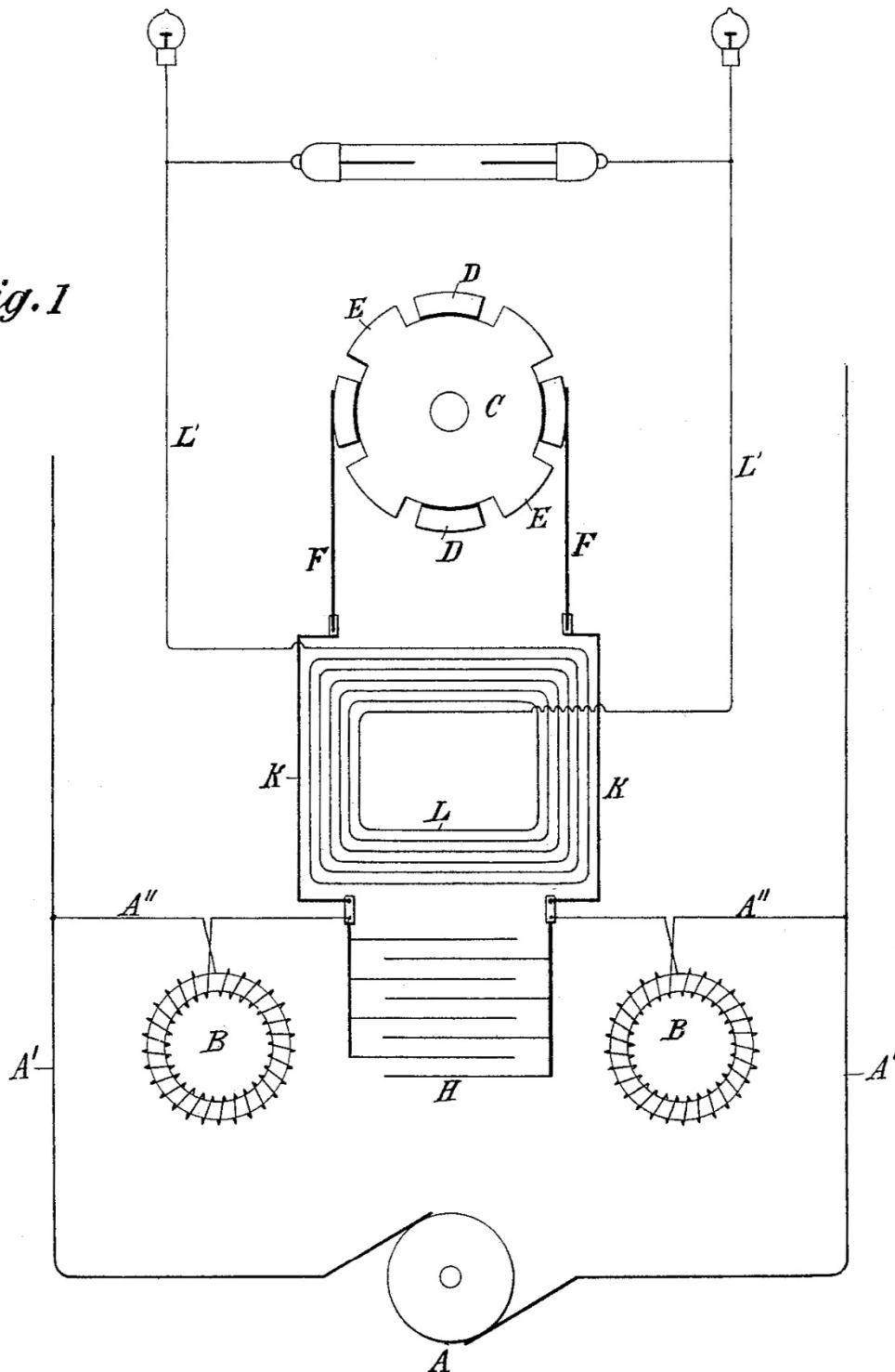
M. LAWSON DYER.

见证人：埃德温·霍普金森、M.劳森·戴尔。

N. TESLA.
 APPARATUS FOR PRODUCING ELECTRIC CURRENTS OF HIGH
 FREQUENCY AND POTENTIAL.

No. 568,176

Patented Sept. 22, 1896.

Fig. 1

Witnesses:
Raphael Ketter
Drury W. Cooper

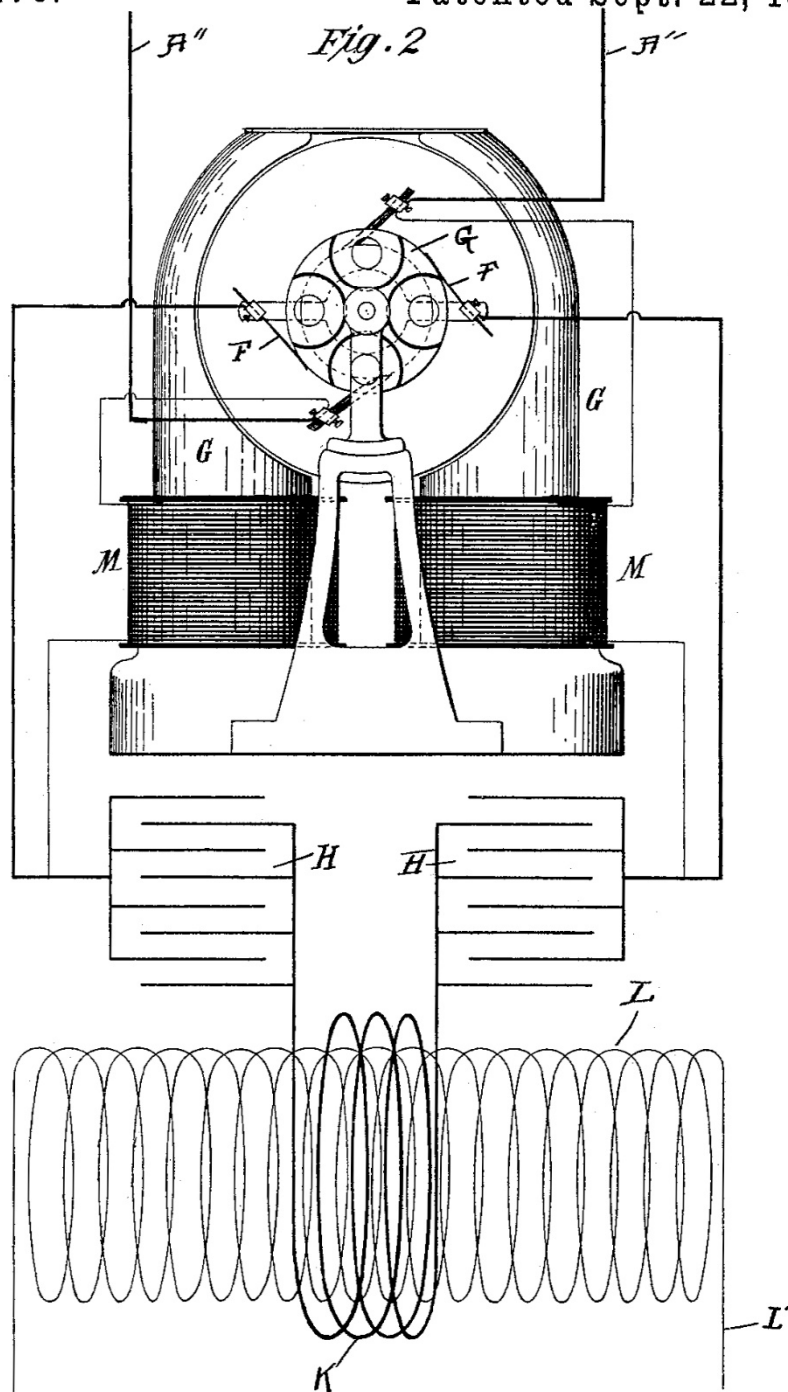
Nikola Tesla, Inventor
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Att'ys.

N. TESLA.

APPARATUS FOR PRODUCING ELECTRIC CURRENTS OF HIGH
FREQUENCY AND POTENTIAL.

No. 568,176.

Patented Sept. 22, 1896.



WITNESSES:

M. Lawson Dyer

Edwin B. Hopkinson

Nikola Tesla INVENTOR

BY

Kerr, Curtis & Page

ATTORNEYS

APPARATUS FOR PRODUCING OZONE.

用于产生臭氧的装置

NIKOLA TESLA, OF NEW YORK, N. Y.

纽约州纽约市的尼古拉·特斯拉

SPECIFICATION forming part of Letters Patent No. 568,177, dated September 22, 1896.

Application filed June 17, 1896. Serial No. 595,927. (No model.)

该说明书形成了颁发于 1896 年 9 月 22 日编号为 568,177 的专利证书的一部分。

申请于 1896 年 6 月 17 日提交，序列号为 595,927。(无模型)

To all whom it may concern:

致所有相关人士：

Be it known that I, NIKOLA TESLA, a citizen of the United States, residing at New York, in the county and State of New York, have invented certain new and useful Improvements in Apparatus for Producing Ozone, of which the following is a specification, reference being had to the drawings accompanying and forming a part of the same.

我、尼古拉·特斯拉、一个美国公民，居住在纽约州纽约郡纽约市，在产生臭氧的装置方面发明了一些新的有用的改进，以下是该发明的一个说明，必须参考随附的图纸，它已形成了该说明书的一部分。

The invention subject of my present application has primarily as its object to provide a simple, cheap, and effective apparatus for the production of ozone or such gases as are obtained by the action of high-tension electrical discharges, although in the application to such purposes of the apparatus heretofore invented by me and designed for the production of electric currents of high frequency and potential I have made certain improvements in such apparatus itself which are novel and useful in other and more general applications of the same. I have heretofore shown and described, notably in Patents No. 462,418, dated November 3, 1891, and No. 454,622, dated June 23, 1891, an apparatus devised for the purpose of converting and supplying electrical energy in a form suited for the production of certain novel electrical phenomena which require currents of higher frequency and potential than can readily or even possibly be developed by generators of the ordinary types or by such mechanical appliances as were theretofore known. This apparatus involved means for utilizing the intermittent or oscillating discharge of the accumulated electrical energy of a condenser or a circuit possessing capacity in what may be designated the “working” circuit or that which contains the translating devices or means for utilizing such currents. In my present improvement I have utilized appliances of this general character under conditions and in combination with certain instrumentalities, hereinafter described, which enable me to produce, without difficulty and at very slight expense, ozone in any desired quantities. I would state the apparatus which I have devised for this purpose is capable of other and highly important uses of a similar nature, so but for purposes of the present case I deem it sufficient to describe its operation and effects when used for the purpose of generating ozone.

我的本申请的发明主题的主要目的是提供一种简单、廉价和有效的装置，用于产生臭氧或通过高压放电作用获得的此类气体，尽管在将迄今为止由我发明并设计用于产生高频和高电位电流的装置应用于这种目的的时候，我已经对这种装置本身进行了某些改进，但在这种装置中的这些改进在其他的和更一般的应用中也是新颖和有用的。迄今为止，我已经展示和描述了一种设计用于转换和供应电能的装置，特别是在 1891 年 11 月 3 日被授予的第 462,418 号专利和在 1891 年 6 月 23 日被授予的第 454,622 号专利中，其形式适合于产生某些新颖的电现象，这些电现象需要的电流要比普通类型的发电机或已知的机械设备容易产生或甚至可能产生的电流具有更高的频率和电势。这种设备涉及到对电容器或具有容量的电路的累积电能的间歇或振荡放电进行利用的装置，所述电路在“工作”电路中或在包含有转换设备或利用此类电流的装置的电路中具有可被指派的电容量。在我目前的改进中，我已经在某些条件下利用了这种一般特征的设备，并结合某些如下文所述的工具，这使我能够毫无困难地以非常小的费用生产任何所需数量的臭氧。我会声明我为此目的设计的设备能够满足类似性质的其他非常重要的用途，但就目前的情况而言，我认为当用于产生臭氧的目的时，描述其操作和效果就足够了。

In the accompanying drawings, illustrative of the principle of construction and mode of operation of my improvement, Figure 1 is a diagrammatic illustration of my invention; and Fig. 2, a view, partly in side elevation and partly in section, of the apparatus as I construct it for practical use.

在说明我的改进的结构原理和操作模式的附图中，图 1 是我的发明的示意图；以及图 2 是我为实际使用而建造的装置的部分侧视图和部分剖面图。

The devices hereinafter described is especially designed for direct application to and use with existing circuits carrying direct currents, such as the ordinary municipal incandescent-lighting circuits.

下文描述的装置特别设计成直接应用于现有的输送直流电的电路，例如普通的市政白炽灯照明电路。

Let A B designate the terminals from any given circuit of this character. In such circuit I connect up an electromagnetic motor C in any of the usual ways. That is to say, the coils of the field and armature may be in series or derivation or wholly independent, and either or both are connected up in the circuit. In the present instance one terminal, as B, is connected to one of the binding-posts, from which the circuit is led through one field-coil, D, the brushes and commutator E, the other field-coil, F, and thence to a brush G, which rests upon a circuit-controller H, consisting in general of a conducting disk or cylinder with insulating-sections in its periphery. The other terminal, as A, connects with a second brush K, bearing on the controller, so that the current which passes through and operates the motor is periodically interrupted. For this reason the iron cores of the motor should be laminated. Around the controller is formed a circuit of low self-induction, which, includes a condenser L and the primary M of a transformer. The circuit, including the motor is of relatively high self-induction, and this property is imparted to it by the coils of the motor, or, when these are not sufficient, by the addition of suitable choking-coils, so that at each break of the motor-circuit a current of high electromotive force will be developed for charging the condenser, which may therefore be small and inexpensive. The condenser discharges through the circuit which is completed through the brushes G K and the controller H, and since the self-induction of this circuit, as well as the capacity of the condenser itself, may be given practically any desired value the frequency of the discharge-current may be adjusted at will. The potential

of the high-frequency discharge-current is raised by a secondary coil N in inductive relation to the primary M. The conductors of such secondary circuit are connected to two insulated conducting-plates P P, and when the apparatus is in operation a discharge in the form of streams will be maintained between such plates, as indicated by the wavy lines in the figures. If air be forced between the plates P P during this discharge, the effectiveness of the apparatus is increased and ozone is generated in large quantities. In order to secure this result, I enclose the said plates P P in a casing R of any proper description, through which a current of air is maintained by a fan S, mounted on the shaft of the motor.

让 A B 表示这个特征的任何给定电路的终端。在这样的电路中，我以任何通常的方式连接一个电磁电动机 C。也就是说，励磁线圈和电枢线圈可以串联，也可以间接连接（通过一个线圈的两个终端进行连接），或者完全独立，并且其中一个或两个在电路中连接。在本例中，一个终端，如 B，被连接到一个接线柱上，从该接线柱电路被引导通过一个励磁线圈 D、电刷和换向器 E、另一个励磁线圈 F，然后到达电刷 G，电刷 G 倚靠在一个电路控制器 H 上，后者通常由一个导电的圆盘或圆柱组成，在其外周有绝缘分段。另一个终端，如 A，它与倚靠在控制器上的第二电刷 K 连接，使得通过并运行电动机的电流被周期性地中断。由于这个原因，电动机的铁芯应该是叠片的。在控制器周围形成一个低自感电路，它包含一个电容器 L 和一个变压器的初级 M。包含电动机在内的电路具有相对较高的自感，这种特性是由电动机的线圈所赋予的，或者当这些线圈不够时，通过添加适当的扼流线圈来赋予，从而在电动机电路的每次断开时，将产生高电动势的电流来给电容器充电，因此电容器可以是小且便宜的。电容器通过由电刷 G K 和控制器 H 构成的电路放电，由于该电路的自感以及电容器本身的电容量实际上可以给出任何所需的值，所以放电电流的频率可以任意调节。高频放电电流的电位由与初级线圈 M 成感应关系的一个次级线圈 N 来升高。这种次级电路的导体连接到两个被绝缘的导电板 P P 上，并且当该装置处于运行状态时，在这两个板之间将保持流光形式的放电，如图中的波浪线所示。如果在放电过程中空气被压入板 P P 之间，设备的效率会增加，并且会产生大量的臭氧。为了确保这个结果，我将所述板 P P 封装在任何适当描述的外壳 R 中，通过该外壳，安装在一个电动机轴上的风扇 S 维持着气流。

This apparatus may be constructed and combined in very compact form and small compass. Its operation involves but a small expenditure of energy, while it requires practically no care or attention for the continued production of ozone in unlimited amount.

该设备可以以非常紧凑的形式和在小范围内来构造和组合。它的运行只需要很少的能量消耗，而它实际上不需要关心或注意臭氧的无限量的持续产生。

What I claim as my invention is—

我主张我的发明是—

1. The combination with a circuit of direct currents, of a controller for making and breaking the same, a motor included in or connected with said circuit so as to increase its self-induction, and driving the said controller, a condenser in a circuit around the controller, and a transformer through the primary of which the condenser discharges, as set forth.

1、一个组合，它包括：直流电流的一个电路；用于接通和断开该电路的一个控制器；被该控制器所包含的一个电动机，它与所述电路连接以增强其自感并驱动所述控制器；还包括一

个变压器，电容器通过该变压器的初级进行放电，如上所述。

2. The combination with a circuit of direct currents, of a controller for making and breaking the same, a series-wound motor having its coils included in said circuit and driving the said controller, a condenser connected with the circuit around the point of interruption therein, and a transformer, the primary of which is in the discharge-circuit of the condenser, as set forth.

2、一个组合，它包括：一个直流电流电路；用于接通和断开该电路的一个控制器；一个串绕电动机，它的线圈被包含在所述电路中，并且该电动机驱动所述控制器；还包括一个电容器，它与上述电路在中断点附近连接；以及一个变压器，其初级在电容器的放电电路中，如上所述。

3. A device for producing ozone comprising in combination, surfaces between which an electrical discharge takes place, a transformer for producing the potential necessary for such discharge, a condenser in the primary circuit of the transformer, a charging circuit, means for charging the condenser by such circuit and discharging it through the primary of the transformer, and a device for maintaining a current of air between the discharge-surfaces, as set forth.

3、一种用于产生臭氧的装置，包括：不同的放电表面，放电发生在它们之间；用于产生这种放电所需电势的一个变压器；该变压器初级电路中的一个电容器；一个充电电路；用于通过这种电路对电容器充电并通过变压器初级将其放电的工具；以及用于维持放电表面之间的空气流的一个设备，如上所述。

4. A device for producing ozone comprising in combination, surfaces between which an electrical discharge takes place, a transformer for producing the potential necessary for such discharge, a condenser in the primary circuit of the transformer, a charging-circuit, means for charging the condenser by such circuit and discharging it through the primary of the transformer, a motor operated by the charging-circuit, and a device operated thereby for maintaining a current of air between the discharge-surfaces, as set forth.

4、一种用于产生臭氧的装置，包括：不同的放电表面，放电发生在它们之间；用于产生这种放电所需电势的一个变压器；该变压器初级电路中的一个电容器；一个充电电路；用于通过这种电路对电容器充电并通过变压器初级将其放电的工具；一个电动机，它由所述充电电路运行；以及一个设备，由该充电电路运行用来维持放电表面之间的空气流，如上所述。

5. A device for producing ozone comprising in combination, surfaces between which an electrical discharge takes place, a transformer for producing the potential necessary for such discharge, a condenser in the primary circuit of the transformer, a charging-circuit, a circuit-controller effecting the charging and discharging of the condenser, and a fan-motor connected with the charging-circuit and operating the circuit-controller and adapted to maintain a current of air between the discharge-surfaces, as set forth.

5、一种用于产生臭氧的装置，包括：不同的放电表面，放电发生在它们之间；用于产生这种放电所需电势的一个变压器；该变压器初级电路中的一个电容器；一个充电电路；一个电路控制器，用来实现电容器的充电和放电；一个风扇电动机，它与充电电路连接并操作电路

控制器并适用于维持放电表面之间的空气流，如前所述。

6. A device for producing ozone comprising in combination, means for charging a condenser, a circuit of low self-induction and resistance into which the condenser discharges, a coil for raising the potential of such discharge, and means for passing a current of air through the high-potential discharge, as set forth.

6、一种用于产生臭氧的装置，包括：用于给电容器充电的工具；一个低自感和低电阻的电路，电容器向该电路放电；一个线圈，用来提高上述放电的电势；用于使空气流通过高电位放电的工具，如上所述。

NIKOLA TESLA.

尼古拉·特斯拉

Witnesses:

DRURY W. COOPER,

M. LAWSON DYER.

见证人：

德鲁里·库珀、M.劳森·戴尔。

(No Model.)

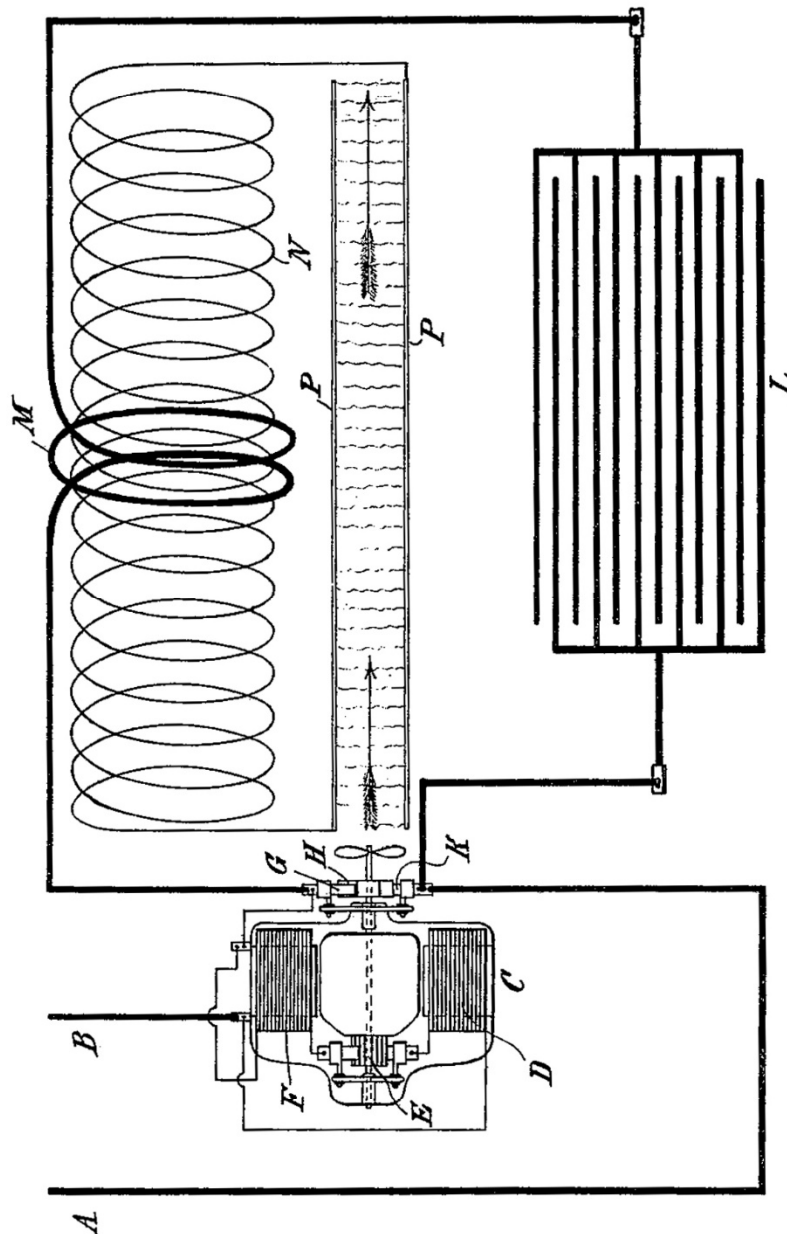
2 Sheets—Sheet 1.

N. TESLA.
APPARATUS FOR PRODUCING OZONE.

No. 568,177.

Patented Sept. 22, 1896.

Fig. 1



Raphaël Vetter
Dury W. Cooper

Nikola Tesla, Inventor
by Kerr, Curtis & Page. Att'ys.

(No Model.)

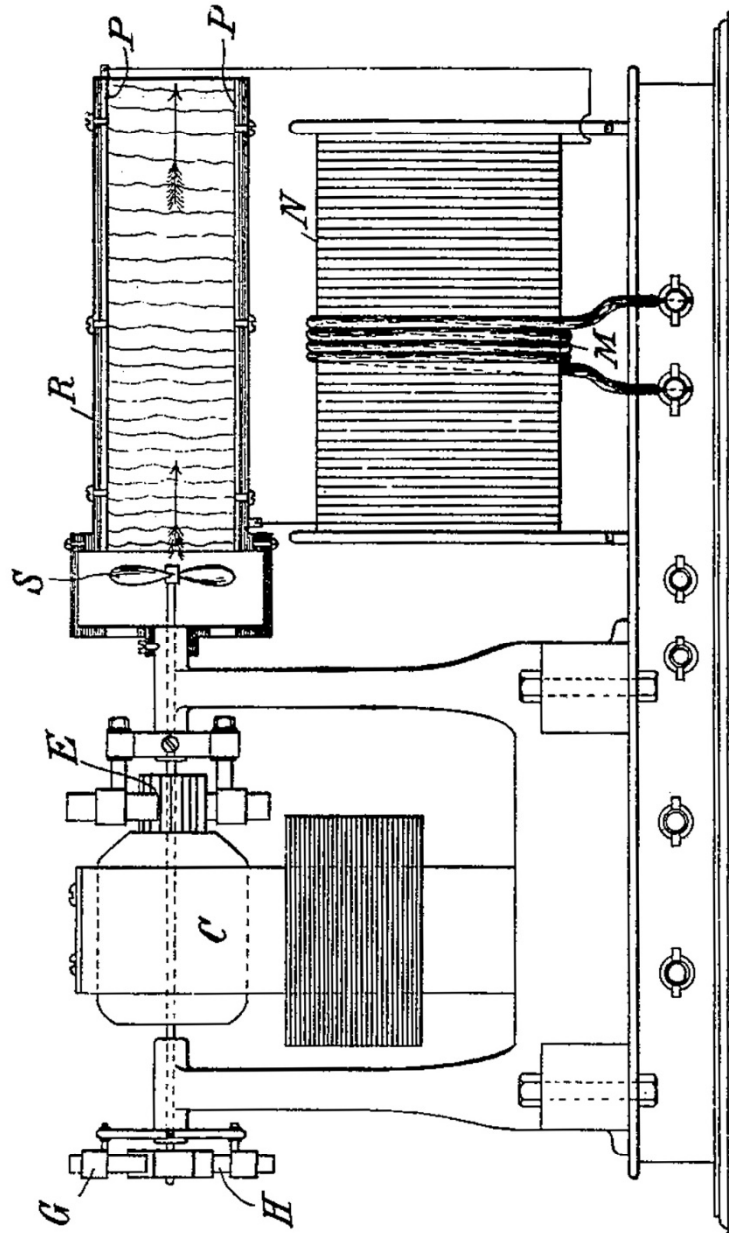
2 Sheets—Sheet 2.

N. TESLA.
APPARATUS FOR PRODUCING OZONE.

No. 568,177.

Patented Sept. 22, 1896.

Fig. 2



Henry N. Cooper

by

Kerr, Curtis & Noyes
Att'ys.

METHOD OF REGULATING APPARATUS FOR PRODUCING CURRENTS OF HIGH FREQUENCY.

调节用于产生高频电流的装置的方法

NIKOLA TESLA, OF NEW YORK, N. Y.

纽约州纽约市的尼古拉·特斯拉

SPECIFICATION forming part of Letters Patent No. 568,178, dated September 22, 1896.

Application filed June 20, 1896. Serial No. 596,262. (No model.)

该说明书形成了颁发于 1896 年 9 月 22 日编号为 568,178 的专利证书的一部分。

原始申请于 1896 年 6 月 20 日提交，序列号为 650,343。(没有模型)。

To all whom it may concern:

致所有相关人士：

Be it known that I, NIKOLA TESLA, a citizen of the United States, residing at New York, in the county and State of New York, have invented certain new and useful Improvements in Methods of Regulating Apparatus for Producing Currents of High Frequency, of which the following is a specification, reference being had to the drawings accompanying and forming a part of the same.

众所周知，我，尼古拉·特斯拉，美国公民，居住在纽约州纽约郡纽约市，在调节用于产生高频电流的装置的方法方面已经发明了某些新的和有用的改进，以下是该发明一个说明书，必须参考随附的参考图纸，它已形成了该说明书的一部分。

In previous patents and applications I have shown and described a method of and apparatus for generating electric currents of high frequency suitable for the production of various novel phenomena, such as illumination by means of vacuum-tubes, the production of ozone, Roentgen shadows, and other purposes. The special apparatus of this character which I have devised for use with circuits carrying currents in the nature of those classed as direct, or such as are generally obtainable from the ordinary circuits used in municipal systems of incandescent lighting, is based upon the following principles:

在以前的专利和申请中，我已经展示并描述了一种用于产生高频电流的方法和装置，该高频电流适合于产生各种新颖的现象，例如通过真空管的照明、臭氧的产生、伦琴阴影以及其他目的。我所设计的这种特点的特殊装置适用于承载电流的电路，这些电流本质上属于直流电流，或者如通常可从市政白炽灯照明系统中使用的普通电路中获得的电流，这种特点的特殊装置基于以下原理：

The energy of the direct-current supply is periodically directed into and stored in a circuit of relatively

high self-induction, and in such form is employed to charge a condenser or circuit of capacity, which, in turn, is caused to discharge through a circuit of low self-induction containing means whereby the intermittent current of discharge is raised to the potential necessary for producing any desired effect. Considering the conditions necessary for the attainment of these results, there will be found, as the essential elements of the system, the supply-circuit, from which the periodic impulses are obtained, and what may be regarded as the local circuits, comprising the circuit of high self-induction for charging the condenser and the circuit of low self-induction into which the condenser discharges and which itself may constitute the working circuit, or that containing the devices for utilizing the current, or may be inductively related to a secondary circuit which constitutes the working circuit proper. These several circuits, it will be understood, may be more or less interconnected; but for purposes of illustration they may be regarded as practically distinct, with a circuit-controller for alternately connecting the condenser with the circuit by which it is charged and with that into which it discharges, and with a primary of a transformer in the latter circuit having its secondary in that which contains the devices operated by the current.

直流电源的能量被周期性地导入并存储在一个相对高自感的电路中,并以这种形式用来给一个电容器或容性电路充电,该电容器或容性电路又通过一个低自感电路放电,该低自感电路包含有将间歇放电电流升高到产生任何所需效果所必需的电位的工具。考虑到获得这些结果所需的条件,将会发现,作为系统的基本组件,用来获得周期性脉冲的供电电路,以及可以被认为是局部电路的电路,包括了用于对电容器充电的高自感电路和使电容器放电的低自感电路,该电路本身可以构成工作电路,或者包含用于利用电流的装置,或者可以与构成工作电路本身的次级电路感应相关。应当理解,这几个电路可以或多或少地相互连接;但是为了说明的目的,它们可以被认为实际上是不同的,具有一个电路控制器,用于交替地将电容器与给电容器充电的电路和电容器的放电所流入的电路连接,并且在后者电路中具有一个变压器的初级,在该变压器的包含了其次级的电路中有一个被该放电电流操作的设备。

To this system or combination the invention, subject of my present application, pertains, and has for its object to provide a proper and economical means of regulation therefore.

对于该系统或组合,我目前的申请的主题涉及(并且因此目的是)提供一种适当且经济的调节工具。

It is well known that every electric circuit, provided its ohmic resistance does not exceed certain definite limits, has a period of vibration of its own analogous to the period of vibration of a weighted spring. In order to alternately charge a given circuit of this character by periodic impulses impressed upon it and to discharge it most effectively, the frequency of the impressed impulses should bear a definite relation to the frequency of vibration possessed by the circuit itself. Moreover, for like reasons the period or vibration of the discharge-circuit should bear a similar relation to the impressed impulses or the period of the charging-circuit. When the conditions are such that the general law of harmonic vibrations is followed, the circuits are said to be in resonance or in electromagnetic synchronism, and this condition I have found in my system to be highly advantageous. Hence in practice I adjust the electrical constants of the circuits so that in normal operation this condition of resonance is approximately attained. To accomplish this, the number of impulses of current directed into the charging-circuit per unit time is made equal to the period of the charging-circuit itself, or, generally, to a harmonic thereof, and the same relations are maintained between the charging and discharge circuit. Any departure from this condition

will result in a decreased output, and this fact I take advantage of in regulating such output by varying the frequencies of the impulses or vibrations in the several circuits.

众所周知,每一个电路,只要它的欧姆电阻不超过某个确定的极限,它都有自己的振动周期,类似于一个加重弹簧的振动周期。为了通过施加在其上的周期性脉冲交替地对具有这种特性的给定电路充电并最有效地对其进行放电,所施加的脉冲的频率应该与电路本身所具有的振动频率具有一定的关系。此外,出于同样的原因,放电电路的周期或振动应该与外加脉冲或充电电路的周期具有相似的关系。当条件符合谐波振动的一般规律时,就可以说电路处于共振或电磁同步,我发现这种条件在我的系统中是非常有利的。因此,在实践中,我调整了电路的电常数,以便在正常操作中近似达到这种谐振条件。为了实现这一点,每单位时间内流入充电电路的电流脉冲数等于充电电路本身的周期,或者通常等于其谐波,并且在充电电路和放电电路之间保持相同的关系。任何偏离这一条件的情况都会导致输出减少,而我利用这一事实,通过改变几个电路中脉冲或振动的频率来调节这种输出。

Inasmuch as the period of any given circuit depends upon the relations of its resistance, self-induction, and capacity, a variation of any one or more of these may result in a variation in its period. There are therefore various ways in which the frequencies of vibration of the several circuits in the system referred to may be varied, but the most practicable and efficient ways of accomplishing the desired result are the following: (a) varying the rate of the impressed impulses of current, or those which are directed from the source of supply into the charging-circuit, as by varying the speed of the commutator or other circuit-controller; (b) varying the self-induction of the charging-circuit; (c) varying the self-induction or capacity of the discharge-circuit.

因为任何给定电路的周期取决于其电阻、自感和电容的关系,因此这些中的任何一个或多个的变化都可能导致其周期的变化。因此,有各种方法可以改变所述系统中几个电路的振动频率,但实现所需结果的最可行和最有效的方法如下:(a)通过改变换向器或其它电路控制器的速度,来改变外加电流脉冲的速率,或改变那些从电源引入充电电路的脉冲的速率;(b)改变充电电路的自感;(c)改变放电电路的自感或容量。

To regulate the output of a single circuit which has no vibration of its own by merely varying its period would evidently require, for any extended range of regulation, a very wide range of variation of period; but in the system described a very wide range of regulation of the output may be obtained by a very slight change of the frequency of one of the circuits when the above-mentioned rules are observed.

仅仅通过改变其周期来调节没有自身振动的单个电路的输出,对于任何扩展的调节范围来说,显然需要一个非常大范围的周期变化;但是在所描述的系统中,当遵守上述规则时,可以通过非常轻微地改变其中一个电路的频率来获得一个非常宽范围的输出调节。

In illustration of my invention I have shown by diagrams in the accompanying drawings some of the more practicable means for carrying out the same. The figures, as stated, are diagrammatic illustrations of the system in its typical form provided with regulating devices of different specific character. These diagrams will be described in detail in their order.

为了说明我的发明,我已经通过附图中的图表展示了用于实现相同目的的一些更可行的工具。如上所述,这些附图是该系统的典型形式的示意图,该系统配备有不同特定特征的调节

装置。这些图将按顺序详细描述。

In each of the figures, A B designate the conductors of a supply-circuit of continuous current; C, a motor connected therewith in any of the usual ways and driving a current-controller D, which serves to alternately close the supply-circuit through the motor or through a self-induction coil E and to connect such motor-circuit with a condenser F, the circuit of which contains a primary coil G, in proximity to which is a secondary coil H, serving as the source of supply to the working circuit, or that in which are connected up the devices K K for utilizing the current.

在每幅图中，A B 表示提供恒向电流的一个供电电路的导线；C 表示以任何通常的方式与 A B 连接并驱动一个电流控制器 D 的电动机，该电流控制器 D 用于交替地闭合通过电动机或通过自感线圈 E 的供电电路，并将这种电动机电路与一个电容器 F 连接，电容器 F 的电路包含一个初级线圈 G，在初级线圈 G 附近是次级线圈 H，用作工作电路的电源，或者在次级线圈 H 中连接有利用次级电流的装置 K K。

The circuit-controller, it may be stated, is any device which will permit of a periodic charging of the condenser F by the energy of the supply-circuit and its discharging into a circuit of low self-induction supplying directly or indirectly the translating devices. Inasmuch as the source of supply is generally of low potential, it is undesirable to charge the condenser directly therefrom, as a condenser of large capacity will in such cases be required. I therefore employ a motor of high self-induction, or in place of or in addition to such motor a choking or self-induction coil E, to store up the energy of the supply-current directed into it and to deliver it in the form of a high-potential discharge when its circuit is interrupted and connected to the terminals of the condenser.

可以说，电路控制器是允许电容器 F 通过供电电路的能量周期性充电并将其放电到直接或间接向转换装置供电的低自感电路中的任何装置。因为电源通常是低电位的，所以不希望从电源给电容器直接充电，因为在这种情况下需要大容量的电容器。因此，我使用一个高自感电动机，或代替这样的电动机，或除了这样的电动机之外，使用一个扼流线圈或自感线圈 E，以存储导入其中的来自电源的电流能量，并在其电路中断并连接到电容器的终端时，以一个高电位放电的形式传递它。

In order to secure the greatest efficiency in a system of this kind, it is essential, as I have before stated, that the circuits, which, mainly as a matter of convenience, I have designated as the “charging” and the “discharge” circuits, should be approximately in resonance or electromagnetic synchronism. Moreover, in order to obtain the greatest output from a given apparatus of this kind, it is desirable to maintain as high a frequency as possible.

为了确保此类系统的最大效率，正如我之前所说，重要的是这种电路，主要是为了方便起见，我将其表示为“充电”电路和“放电”电路，应该近似谐振或电磁同步。此外，为了从这种给定的设备中获得最大的输出，希望保持尽可能高的频率。

The electrical conditions, which are now well understood, having been adjusted to secure, as far as practical considerations will permit, these results, I effect the regulation of the system by adjusting its elements so as to depart in a greater or less degree from the above conditions with a corresponding variation of output.

现在已经很好理解的电气条件已被调整，只要实际考虑允许，就要确保这些结果，我通过调整其组件来实现系统的调节，以便或多或少地偏离上述条件，并形成一個相应的输出变化。

For example, as in Figure 1, I may vary the speed of the motor, and consequently of the controller, in any suitable manner, as by means of a rheostat L in a shunt to such motor or by shifting the position of the brushes on the main commutator M of the motor or otherwise.

例如，如图 1 所示，我可以以任何合适的方式改变电动机的速度，从而改变控制器的速度，例如通过与这种电动机并联的变阻器 L，或者通过移动电动机的主换向器 M 上的电刷位置，或者其他方式。

A very slight variation in this respect, by disturbing the relations between the rate of impressed impulses and the vibration of the circuit of high self-induction into which they are directed, causes a marked departure from the condition of resonance and a corresponding reduction in the amount of energy delivered by the impressed impulses to the apparatus.

在这方面的一个非常微小的变化，通过扰乱外加脉冲的速率与这些脉冲被导向到的高自感电路的振动之间的关系，导致明显偏离共振条件，并相应地减少由外加脉冲传递到装置的能量。

A similar result may be secured by modifying any of the constants of the local circuits, as above indicated. For example, in Fig. 2 the choking coil E is shown as provided with an adjustable core N, by the movement of which into and out of the coil the self-induction, and consequently the period of the circuit containing such coil, may be varied.

如上所述，通过修改局部电路的任何常数，可以获得类似的结果。例如，在图 2 中，扼流线圈 E 被展示为配有一个可调节的磁芯 N，通过磁芯 N 进出线圈的运动，可以改变自感，从而改变包含这种线圈的电路的周期。

As an example of the way in which the discharge-circuit, or that into which the condenser discharges, may be modified to produce the same result I have shown in Fig. 3 an adjustable self-induction coil R in the circuit with the condenser, by the adjustment of which the period of vibration of such circuit may be changed.

作为放电电路或电容器放电的方式的一个例子，可以修改放电电路以产生相同的结果，我在图 3 中展示出在电路中带有该电容器的一个可调自感线圈 R，通过调整它，可以改变这种电路的振动周期。

The same result would be secured by varying the capacity of the condenser; but if the condenser were of relatively large capacity this might be an objectionable plan, and a more practicable method is to employ a variable condenser in the secondary or working circuit, as shown in Fig. 4. As the potential in this circuit is raised to a high degree, a condenser of very small capacity may be employed, and if the two circuits, primary and secondary, are very intimately and closely connected the variation of capacity in the secondary is similar in its effects to the variation of the capacity of the condenser in the primary. I have illustrated as a means well adapted for this purpose two metallic plates S S, adjustable to and from each other and constituting the two armatures of the condenser.

通过改变电容器的容量可以获得相同的结果；但如果电容器的容量相对较大，这个方案可能并不可取，一个更可行的方法是在次级或工作电路中采用一个可变电容器，如图 4 所示。当这个电路中的电位升高到一个很高的程度时，可以使用一个容量非常小的电容器，如果初级和次级这两个电路非常紧密地连接在一起，次级中的容量变化与初级中的容量变化在影响上是相似的。我已经举例说明了两个金属板 SS 作为一种非常适合此目的的工具，它们可以相互调节并构成电容器的两个电容极板。

I have confined the description herein to a source of supply of direct current, as to such the invention more particularly applies, but it will be understood that if the system be supplied by periodic impulses from any source which will effect the same results the regulation of the system may be effected by the method herein described, and this my claims are intended to include.

我已经将这里的描述局限于一个直流电源，因为本发明更具体地应用于这种电源，但是应该理解，如果系统由来自任何电源的周期性脉冲供电，这将实现相同的结果，则系统的调节可以通过这里描述的方法来实现，并且这是我的主张想要包括的。

What I claim is—

我主张的是—

1. The method of regulating the energy delivered by a system for the production of high-frequency currents and comprising a supply-circuit, a condenser, a circuit through which the same discharges and means for controlling the charging of the condenser by the supply-circuit and the discharging of the same, the said method consisting in varying the relations of the frequencies of the impulses in the circuits comprising the system, as set forth.

1、用于产生高频电流的系统所输送的能量的调节方法，该系统包括一个供电电路；一个电容器；一个电路，该电容器通过该电容器进行放电；以及用于控制供电电路对电容器充电和放电的工具；所述方法包括改变构成该系统的电路中的脉冲频率关系，如上所述。

2. The method of regulating the energy delivered by a system for the production of high-frequency currents comprising a supply-circuit of direct currents, a condenser adapted to be charged by the supply-circuit and to discharge through another circuit, the said method consisting in varying the frequency of the impulses of current from the supply-circuit, as set forth.

2、用于产生高频电流的系统所输送的能量的调节方法，该系统包括一个直流供电电路；适于由电源电路充电并通过另一电路放电的一个电容器；所述方法包括改变来自供电电路的电流脉冲的频率，如上所述。

3. The method of producing and regulating electric currents of high frequency which consists in directing impulses from a supply-circuit into a charging-circuit of high self-induction, charging a condenser by the accumulated energy of such charging-circuit, discharging the condenser through a circuit of low self-induction, raising the potential of the condenser discharge and varying the relations of the frequencies of the electrical impulses in the said circuits, as herein set forth.

3、产生和调节高频电流的方法，包括将脉冲从供电电路引入一个高自感的充电电路；通过这种充电电路累积的能量对一个电容器充电；通过一个低自感电路对该电容器放电；提高该电容器放电的电势，并改变所述电路中电脉冲的频率关系，如本文所述。

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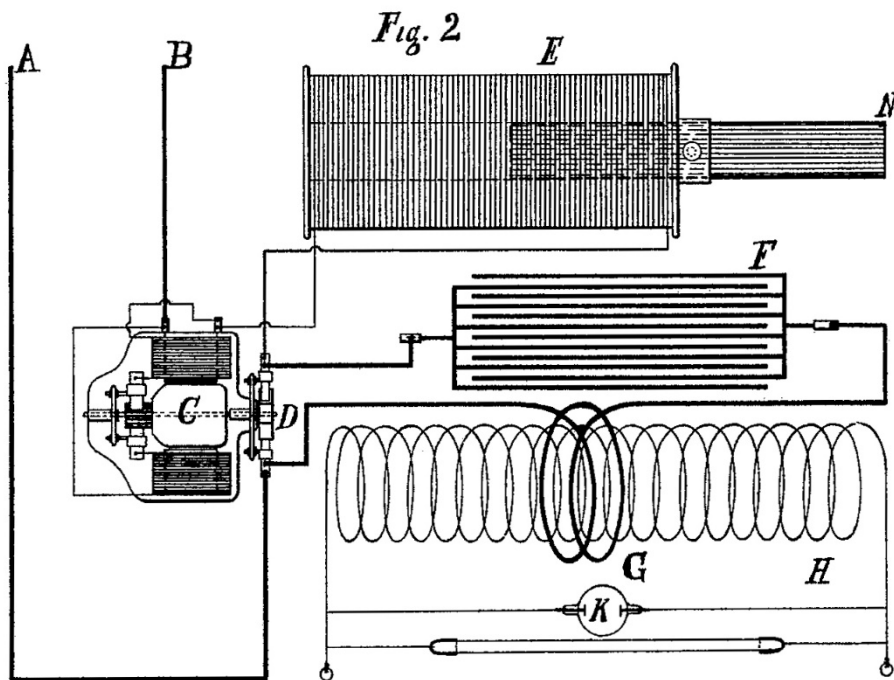
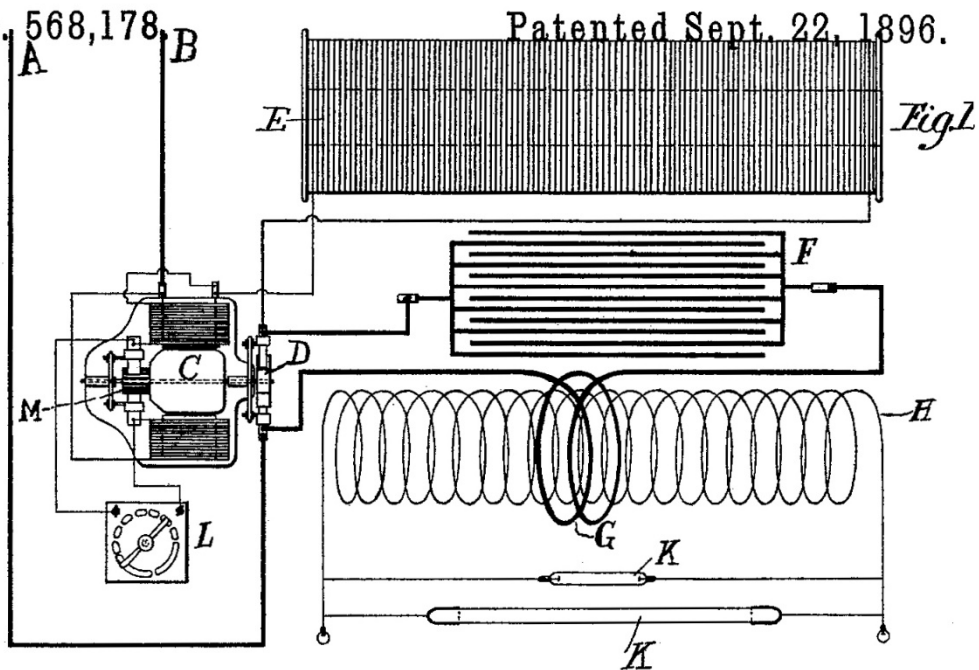
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N. TESLA.

METHOD OF REGULATING APPARATUS FOR PRODUCING CURRENTS
OF HIGH FREQUENCY.

No. 568,178.

Patented Sept. 22, 1896.



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Fig. 3.

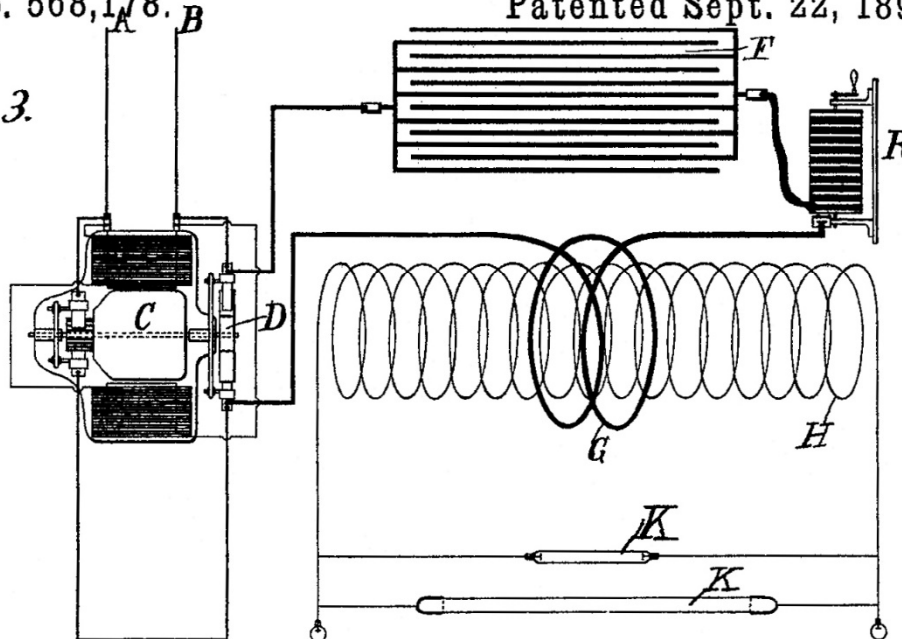
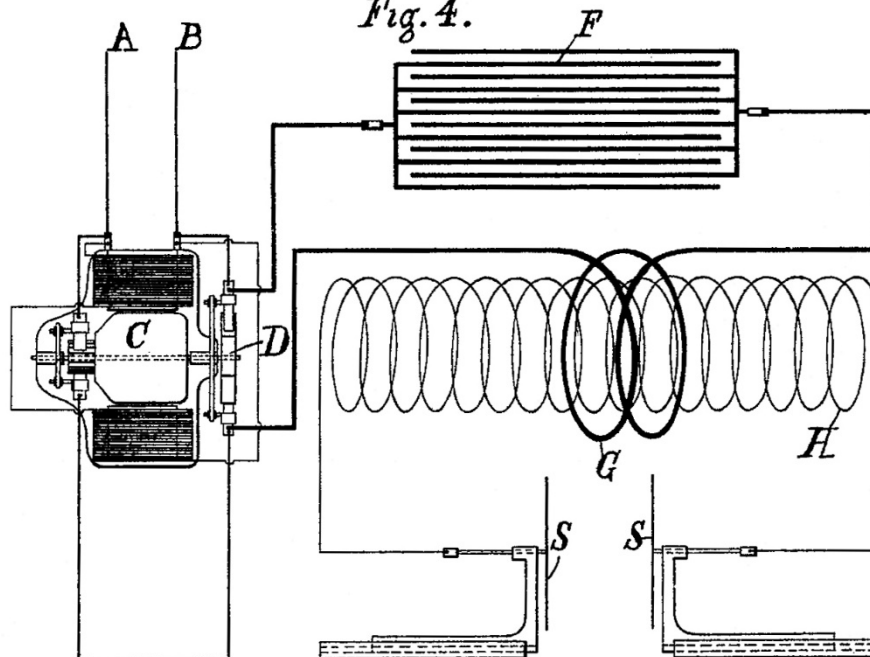


Fig. 4.



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METHOD OF AND APPARATUS FOR PRODUCING CURRENTS OF HIGH FREQUENCY

用于产生高频电流的方法和装置

NIKOLA TESLA, OF NEW YORK, N. Y.

纽约州纽约市的尼古拉·特斯拉

SPECIFICATION forming part of Letters Patent No. 568,179, dated September 22, 1896.

Application filed July 6, 1896. Serial No. 598,130. (No model.)

该说明书形成了颁发于1896年9月22日编号为568,179的专利证书的一部分。

申请于1896年9月22日提交。序列号598,130。(没有模型)

To all whom it may concern:

致所有相关人士:

Be it known that I, NIKOLA TESLA, a citizen of the United States, residing at New York, in the county and State of New York, have invented certain new and useful Improvements in Methods of and Apparatus for Producing Currents of High Frequency, of which the following is a specification, reference being had to the drawings accompanying and forming a part of the same.

众所周知，我、尼古拉·特斯拉，一个美国公民，居住在纽约州纽约郡纽约市，在用于产生高频电流的方法和装置方面发明了某种新的和有用的改进，以下是该发明一个说明书，必须参考随附的图纸，它已形成了该说明书的一部分。

The apparatus for producing electrical currents of very high frequency in which is embodied the invention of my present application involves as its chief element means for the periodic charging of a condenser or circuit possessing capacity by the energy of a given source and the discharge of the same through a circuit of low self-induction, whereby the rapid succession of impulses characteristic of a condenser discharge under such circumstances is made available for many practical and useful purposes.

体现本申请的发明的用于产生甚高频电流的设备包括作为其主要组件的装置，用于通过给定电源的能量对具有容量的电容器或电路进行周期性充电，并通过低自感电路对其进行放电，由此在这种情况下，电容器放电的快速连续脉冲特性可用于许多实际和有用的目的。

The general arrangement of circuits and apparatus which I prefer for ordinary applications of this invention I have shown and described in an application filed by me April 22, 1896, Serial No. 588,534, as comprising a local circuit of high self-induction connected with a source of supply, a condenser, a discharge-circuit of low self-induction, and a circuit-controller operating to alternately effect the charging of the condenser by the energy stored in the circuit of high self-induction and its discharge

through that of low self-induction. I have shown, however, in the application referred to as the source of supply a continuous-current generator, or in general a source of direct currents, and while the principle of operation and the general character of the apparatus remain the same whether the current of the source be direct or alternating, yet the economical utilization of the latter involves certain special principles and appliances which it is my present object to illustrate as the basis for the claims of invention made herein.

我在 1896 年 4 月 22 日提交的序列号为 588,534 的申请中已经展示和描述了我更喜欢用于本发明的普通应用的电路和装置的总体布置, 包括与一个电源连接的高自感的一个局部电路、一个电容器、一个低自感的放电电路和一个电路控制器, 操作该电路控制器交替地利用存储在高自感电路中的能量实现对电容器的充电和通过低自感电路实现对电容器的放电。然而, 在被称为电源的应用中, 我已经展示了一种恒向电流发电机, 或通常的直流电源, 并且尽管无论电源的电流是直流还是交流, 该装置的操作原理和一般特征都保持相同, 但是交流的经济利用涉及某些特殊的原理和设备, 这是我目前的目的, 用来说明本发明的权利主张的基础。

When the potential of the source periodically rises and falls, whether with reversals or not is immaterial, it is essential to economical operation that the intervals of interruption of the charging-current should bear a definite time relation to the period of the current, in order that the effective potential of the impulses charging the condenser may be as high as possible. I therefore provide, in case an alternating or equivalent electromotive force be employed as the source of supply, a circuit-controller which will interrupt the charging-circuit at instants predetermined with reference to the variations of potential therein. The most practicable means for accomplishing this of which I am aware is to employ a synchronous motor connected with the source of supply and operating a circuit-controller which interrupts the charging-current at or about the instant of highest potential of each wave and permits the condenser to discharge the energy stored in it through its appropriate circuit. This apparatus, which may be considered as typical of the means employed for carrying out the invention, I have illustrated in the accompanying drawings.

当电源的电势周期性地上升和下降时, 是否带有反转都是不重要的, 对于经济运行来说, 充电电流的中断的间隔期应该与电流的周期具有确定的时间关系, 以便使对电容器充电的脉冲的有效电势尽可能高。因此, 我提供了一种电路控制器, 在使用交流或等效电动势作为电源的情况下, 该电路控制器将根据充电电路中电势的变化在预定的时刻中断充电电路。据我所知, 实现这一点的最切实可行的方法是采用一个与电源连接的同步电动机, 并操作一个电路控制器, 该控制器在每个波的最高电位时刻或其附近中断充电电流, 并允许电容器通过其适当的电路释放存储在其中的能量。我已经在附图中展示了这种装置, 它可以被认为是用于实施本发明的典型装置。

The figures are diagrammatic illustrations of the system in slightly-modified forms, and will be described in detail in their order.

这些图是系统的略加改进的示意图, 将按顺序详细描述。

Referring to Figure 1, A designates any source of alternating or equivalent current, from which lead off mains A' A'. At any point where it is desired to produce the high-frequency currents a branch circuit B is taken-off from the mains, and in order to raise the potential of the current a transformer is employed,

represented by the primary C and secondary D. The circuit of the secondary includes the energizing-coils of a synchronous motor E and a circuit-controller, which, in the present instance, in Fig. 1 is shown as composed of a metal disk F with insulated segments F' in its periphery and fixed to the shaft of the motor. An insulating-arm G, stationary with respect to the motor-shaft and adjustable with reference to the poles of the fixed magnets, carries two brushes H H, which bear upon the periphery of the disk. With the parts thus arranged the secondary circuit is completed through the coils of the motor whenever the two brushes rest upon the uninsulated segments of the disk and interrupted through the motor at other times. Such a motor, if properly constructed, in well-understood ways, maintains very exact synchronism with the alternations of the source, and the arm G may therefore be adjusted to interrupt the current at any determined point in its waves. It will be understood that by the proper relations of insulated and conducting segments and the motor-poles the current may be interrupted twice in each complete wave at or about the points of highest potential. The self-induction of the circuit containing the motor and controller should be high, and the motor itself will usually be constructed in such manner that no other self-induction device will be needed. The energy stored in this circuit is utilized at each break therein to charge a condenser K. With this object the terminals of the condenser are connected to the two brushes H H or to points of the circuit adjacent thereto, so that when the circuit through the motor is interrupted the terminals of the motor-circuit will be connected with the condenser, whereby the latter will receive the high-potential inductive discharge from the motor or secondary circuit.

参考图 1, A 表示任何交流或等效电流的来源,从电源 A' A'引出。在任何需要产生高频电流的地方,从干线上取下一个分支电路 B,并且为了提高电流的电势,使用一个变压器,用初级 C 和次级 D 表示。次级线圈的电路包括一个同步电动机 E 的激励线圈和电路控制器,在本例中,在图 1 中展示的电路控制器由一个金属盘 F 组成,该金属盘在其外围具有绝缘分段 F',该金属盘被固定在电动机的轴上。一个绝缘臂 G 相对于电机轴静止,并可参考被固定磁铁的磁极进行调节,该绝缘臂带有两个电刷 H H,这两个电刷倚靠在圆盘的外周上。利用如此布置的部件,每当两个电刷停留在圆盘的未绝缘分段上时,次级电路通过电动机的线圈变得完整,而在其它时候通过该电动机断开。这样一个电动机,如果以众所周知的方式适当地构造,可以保持与电源的变化非常精确的同步,并且臂 G 因此可以被调整到在其波的任何确定的点中断电流。可以理解的是,通过绝缘和导电分段与电动机磁极的适当关系,电流可以在每个完整波中在最高电位点处或附近被中断两次。包含电动机和控制器的电路的自感应应该很高,并且电动机本身通常以不需要其他自感装置的方式进行构造。存储在这个电路中的能量在每次中断时被用来给电容器 K 充电为此目的,电容器的终端连接到两个电刷 H H 或与其相邻的电路点,从而当通过电动机的电路中断时,电动机电路的终端将与电容器连接,由此后者将接收来自电动机或次级电路的高电势感应放电。

The condenser discharges into a circuit of low self-induction, one terminal of which is connected directly to a condenser-terminal and the other to the brush H opposite to that connected with the other condenser-terminal, so that the discharge-circuit of the condenser will be completed simultaneously with the motor-circuit and interrupted while the motor-circuit is broken and the condenser being charged.

电容器放电进入一个低自感电路,该电路的一个终端直接连接到一个电容器终端,该电路的另一终端连接到电刷 H,电刷 H 与该电容器另一个终端连接的电刷相对放置,这样该电容器的放电电路将与电动机电路同步完成,并且在电动机电路断开并且电容器充电时被中断。

The discharge-circuit contains a primary M of a few turns, and this induces in a secondary N impulses of high potential, which by reason of their great frequency are available for the operation of vacuum-tubes P, single terminal-lamps R, and other novel and useful purposes.

放电电路包含一个具有几匝线圈的初级 M，它在一个次级 N 中感应出高电势脉冲，由于它们的高频率，这些脉冲可用于真空管 P、单极灯 R 的操作，以及其他新颖和有用的目的。

It is obvious that the supply-current need not be alternating, provided it be converted or transformed into an alternating current before reaching the controller. For example, the present improvements are applicable to various forms of rotary transformers, as is illustrated in Figs. 2 and 3.

很明显，电源电流不一定是交流电，只要在到达控制器之前将其转换或变换成交流电即可。例如，本改进适用于各种形式的旋转变换器，如图 2 和 3 所示。

E' designates a continuous-current motor, here represented as having four field-poles wound with coils E" in shunt to the armature. The line-wires B B connect with the brushes b b, bearing on the usual commutator.

E' 表示一台恒向电流电动机，这里表示为具有四个场磁极，其上缠绕线圈 E"，线圈"与电枢并联。线路导线 B B 与电刷 b b 连接，后者倚靠在通用换向器上。

On an extension of the motor-shaft is a circuit-controller composed of a cylinder the surface of which is divided into four conducting-segments c and four insulating-segments d, the former being diametrically connected in pairs, as shown in Fig. 3.

如图 3 所示，在电动机轴的一个延伸部分上是由圆柱组成的一个电路控制器，圆柱的表面被分成四个导电分段 c 和四个绝缘分段 d，导电分段成对地径向连接。

Through the shaft run two insulated conductors e e from any two commutator-segments ninety degrees apart, and these connect with the two pairs of segments c, respectively. With such arrangement it is evident that any two adjacent segments c c become the terminals of an alternating-current source, so that if two brushes H H be applied to the periphery of the cylinder they will take off current during such portion of the wave as the width of segment and position of the brushes may determine. By adjusting the position of the brushes relatively to the cylinder, therefore, the alternating current delivered to the segments c c may be interrupted at any point in its waves.

来自任意两个相隔 90 度的换向器分段的两个被绝缘导体 e e 穿过电动机轴，分别与两对换向器分段 c 连接。有了这种布置，很明显，任何两个相邻的分段 c c 都成为交流电源的终端，因此，如果两个电刷 H H 被应用到圆柱的外周，则它们将在由分段的宽度和电刷的位置决定的波的这部分期间取走电流。因此，通过调整电刷相对于圆柱的位置，输送到分段 c c 的交流电可以在该交流电的波的任何一点被中断。

While the brushes H H are on the conducting-segments the current which they collect stores energy in a circuit of high self-induction formed by the wires f f, self-induction coils S S, the conductors B B, the brushes, and commutator. When this circuit is interrupted by the brushes H H passing onto the

insulating-segments of the controller, the high-potential discharge of this circuit charges the condensers K K, which then discharge through the circuit of low self-induction containing the primary M. The secondary circuit N contains any devices, as P R, for utilizing the current.

当电刷 H H 在导电段上时，它们收集的电流将能量存储在由导线 f f、自感应线圈 S S、导体 B B、电刷和换向器形成的高自感应电路中。当该电路被通过控制器绝缘段的电刷 H H 中断时，该电路的高电位放电对电容器 K K 充电，然后电容器 K K 通过包含初级 M 的低自感电路放电。次级电路 N 包含任何利用电流的任何装置，如 P R。

The mechanical construction of the circuit-controller may be greatly varied, and in other respects the details shown and described are merely given as typical illustrations of the nature and purpose of the invention.

电路控制器的机械结构可以有很大的变化，在其他方面，所展示和描述的细节仅仅是作为本发明的本质和目的的典型说明而给出的。

What I claim is—

我主张的是—

1. The method herein described of producing electric currents of high frequency, which consists in generating an alternating current, charging a condenser thereby during determinate intervals of each wave of said current, and discharging the condenser through a circuit of low self-induction, as herein set forth.

1、这里描述的产生高频电流的方法，它包括产生一个交流电流，从而在所述电流的每个波的确定的时间间隔期间对电容器充电，并通过低自感电路对电容器放电，如这里所述。

2. The combination with a source of alternating current, a condenser, a circuit-controller adapted to direct the current during determinate intervals of each wave into the condenser for charging the same, and a circuit of low self-induction into which the condenser discharges, as set forth.

2、一个组合，它包括一个交流电源；一个电容器；适于在每个波的确定的时间间隔期间将电流导入电容器以对其充电的一个电路控制器；以及电容器放电的低自感电路，如上所述。

3. The combination with a source of alternating current, a synchronous motor operated thereby, a circuit-controller operated by the motor and adapted to interrupt the circuit through the motor at determinate points in each wave, a condenser connected with the motor-circuit and adapted on the interruption of the same to receive the energy stored therein, and a circuit into which the condenser discharges, as set forth.

3、一个组合，它包括一个交流电源；由该电源操作的一个同步电动机；由电动机操作的，并适于在每个波中的确定点中断通过电动机的电路的一个电路控制器；与电动机电路连接的一个电容器，适于在电动机电路中中断时接收存储在其中的能量；以及电容器的放电所进入的一个电路，如上所述。

4. The combination with a source of alternating current, a charging-circuit in which the energy of said current is stored, a circuit-controller adapted to interrupt the charging-circuit at determinate points in each wave, a condenser for receiving, on the interruption of the charging-circuit, the energy accumulated therein, and a circuit into which the condenser discharges when connected therewith by the circuit-controller, as set forth.

4、一个组合，它包括一个交流电源；存储所述电流能量的一个充电电路；适于在每个波确定点中断充电电路的一个电路控制器；用于在充电电路中断时接收其中累积的能量的一個电容器；以及该电容器的放电所进入的一个电路，当电容器通过电路控制器与该电路连接时，电容器向它放电，如上所述。

NIKOLA TESLA.

尼古拉·特斯拉

Witnesses:

M. LAWSON DYER,
DRURY W. COOPER.

见证人:

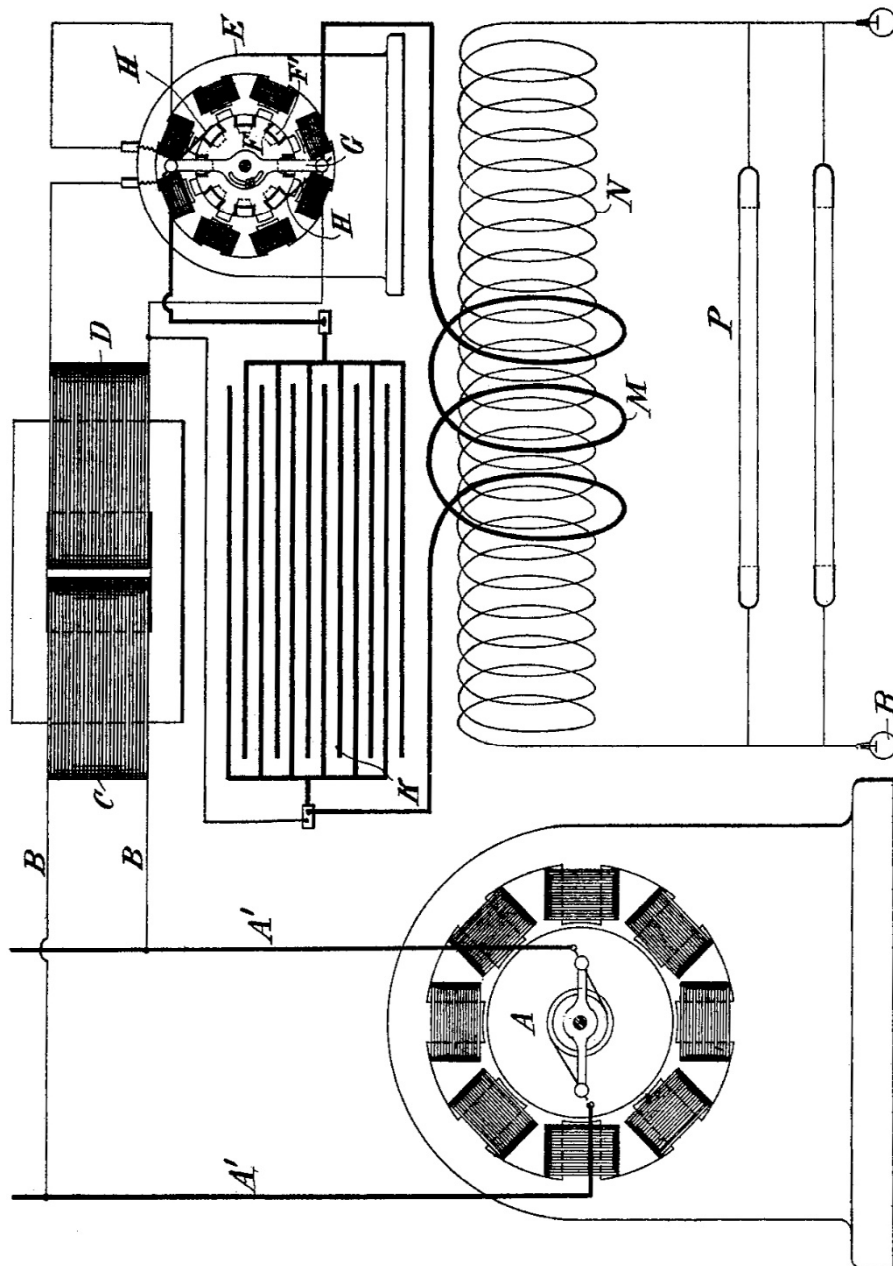
M.劳森·戴尔、德鲁里·W·库珀。

N. TESLA.
METHOD OF AND APPARATUS FOR PRODUCING CURRENTS OF
HIGH FREQUENCY.

No. 568,179.

Patented Sept. 22, 1896.

Fig. 1



WITNESSES

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Edwin B. Hopkinson.

INVENTOR

Nikola Tesla

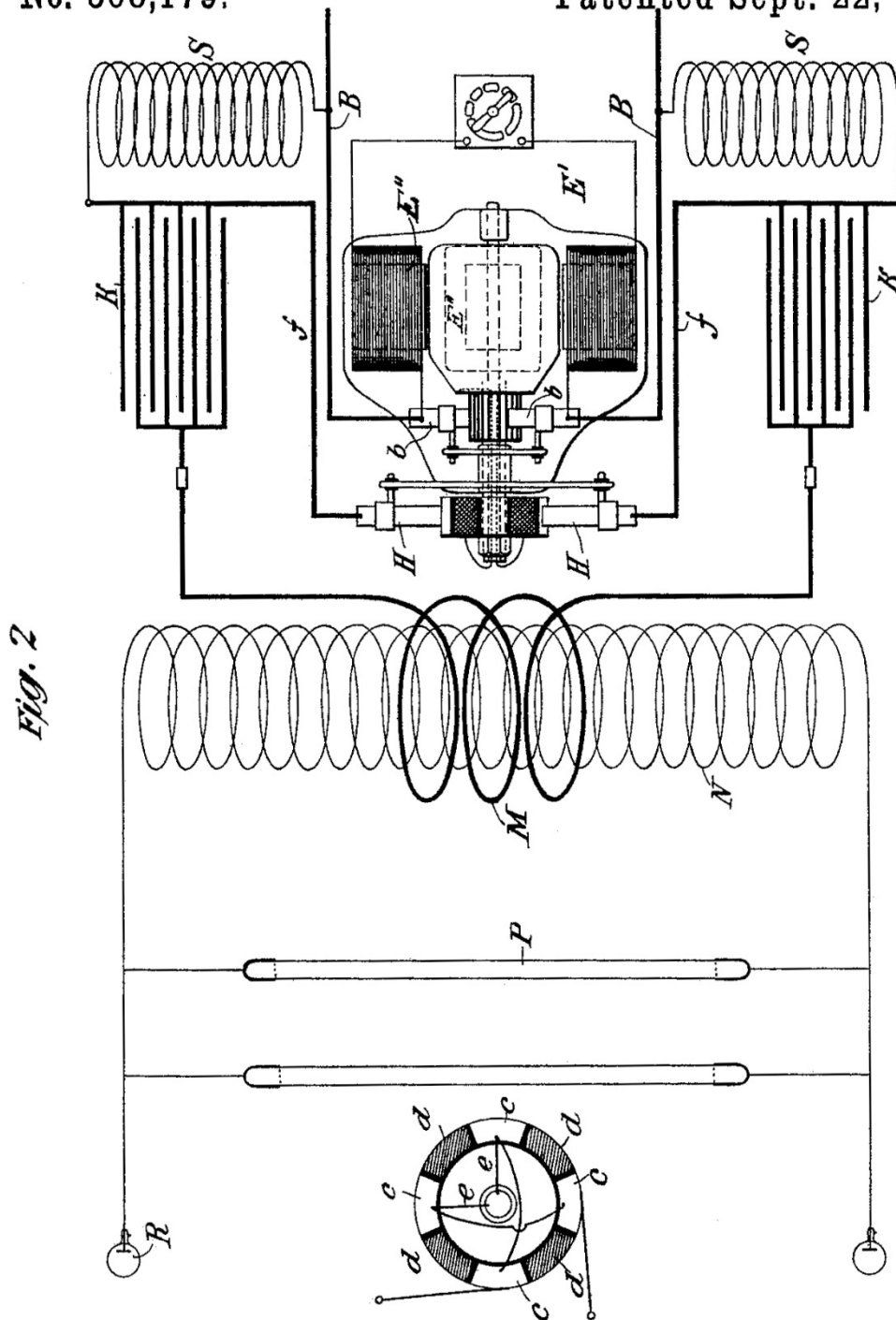
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METHOD OF AND APPARATUS FOR PRODUCING CURRENTS OF
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No. 568,179.

Patented Sept. 22, 1896.



WITNESSES

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INVENTOR

Nikola Tesla
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APPARATUS FOR PRODUCING ELECTRICAL CURRENTS OF HIGH FREQUENCY.

用于产生高频电流的装置

NIKOLA TESLA, OF NEW YORK, N. Y.

纽约州纽约市的尼古拉·特斯拉

SPECIFICATION forming part of Letters Patent No. 568,180, dated September 22, 1896.

Application filed July 9, 1896. Serial No. 598,552. (No model.)

该说明书形成了颁发于 1896 年 9 月 22 日编号为 568,180 的专利证书的一部分。

原始申请于 1896 年 7 月 9 日提交，序列号为 598,552。(没有模型)

To all whom it may concern:

致所有相关人士：

Be it known that I, NIKOLA TESLA, a citizen of the United States, residing at New York, in the county and State of New York, have invented certain new and useful Improvements in Apparatus for Producing Electric Currents of High Frequency, of which the following is a specification, reference being had to the drawings accompanying and forming a part of the same.

众所周知，我、尼古拉·特斯拉，一位美国公民，居住在纽约州纽约郡纽约市，在用于产生高频电流的装置方面已经发明了某些新的和有用的改进，以下是该发明一个说明书，必须参考随附的图纸，它已形成了该说明书的一部分。

This invention is an improvement in apparatus for producing electrical currents of high frequency in accordance with the general plan heretofore invented and practiced by me and based upon the principle of charging a condenser or circuit possessing capacity and discharging the same through a circuit of low self-induction, so that rapid electrical oscillations are obtained. To secure this result, I employ some means for intermittently charging the condenser and for discharging it through the circuit of low self-induction; and among the means which I have heretofore employed for this purpose was a mechanical contact device which controlled both the charging and the discharge circuit in such manner that the condenser was alternately charged by the former and discharged into the latter.

本发明是对用于产生高频电流的装置的改进，该装置与迄今为止由我发明和实践的总体方案一致，并且基于对具有电容量的电容器或电路充电并通过低自感电路放电的原理，从而获得快速电振荡。为了确保这个结果，我采用一些工具来间歇地给电容器充电，并通过低自感电路将其放电；在我迄今为止用于这个目的工具是一个机械接触装置，它控制充电和放电电路，使得电容器交替地被充电前者并向后者放电。

My present improvement consists in an apparatus for effecting the same result by the use of a circuit-controller of special character in which the continuity of the paths for the current is established at intervals by the passage of sparks across a dielectric.

我目前的改进在于能通过使用特殊特性的一个电路控制器来实现相同结果的一种装置,在该装置中,电流通路的连续性是利用火花穿过电介质所形成的通道间隔地建立的。

In carrying out my present improvement I employ a circuit-controller containing two terminals or sets of terminals movable with respect to each other into and out of proximity, and I provide means whereby the intervals between the periods of close approximation, during which the spark passes, may be adjusted so that when used in a system supplied by a source of alternating current the periods of make and break may be timed with reference to a phase of the current wave or impulse.

在进行本发明的改进中,我采用了一种电路控制器,该电路控制器包含两个终端或两组终端,这些终端可相对于彼此靠近或远离,并且我提供了一种工具,由这种装置方法可以调节火花通过间隙的紧密接近的周期之间的时间间隔,使得当在由一个交流电源供电的一个系统中使用这种装置时,可以参考电流波或脉冲的相位来定时接通和断开的時間。

Referring to the drawings, which illustrate in its preferred form the improvement above referred to, Figure 1 is a view, partly in elevation and partly in section, of a generator arranged to give an alternating current with the circuit-controller mounted on its shaft. Fig. 2 is a section of the controller of Fig. 1 on line x x of said figure. Fig. 3 is a diagram illustrating the system or apparatus as a whole. Figs. 4 and 5 are sectional views of a modified form of circuit-controller.

参照这些附图,这些附图以其首选形式展示了上面提到的改进,图1是发电机的一部分正视图和一部分截面图,该发电机被布置成提供交流电,电路控制器安装在其轴上。图2是图1的控制器在所述图的线x x上的截面图。图3是整个的系统或设备的示意图。图4和图5是电路控制器的改进形式的截面图。

A designates in Fig. 1 a generator having a commutator A' and brushes A" bearing thereon, and also collecting-rings B B, from which an alternating current is taken by brushes B' in the well-understood manner.

在图1中,A表示一个发电机,该发电机具有一个换向器A'和倚靠在其上的电刷A",以及集电环B B,电刷B'以众所周知的方式从集电环B B获得交流电。

The circuit-controller is mounted in part on an extension of the shaft C of the generator, and in part on the frame of the same, or on a stationary sleeve surrounding the shaft. Its construction in detail is as follows: D is a metal plate with a central hub D', which is keyed or clamped to the shaft C. The plate is formed with segmental extensions corresponding in number to the waves of current which the generator delivers. These segments are preferably cut away, leaving only rims or frames, to one of the radial sides of which are secured bent metal plates E, which serve as vanes to maintain a circulation of air when the device is in operation. The segmental disk and vanes are contained within a close insulated box or case F, mounted on the bearing of the generator, or in any other proper way, but so as to be capable of angular adjustment around the shaft. To facilitate such adjustment, a screw-rod F', provided

with a knob or handle, is shown as passing through the wall of the box. The latter may be adjusted by this rod, and when in proper position may be held therein by screwing the rod down into a depression in the sleeve or bearing, as shown in Fig. 1. Air-passages G G are provided at opposite ends of the box, through which air is maintained in circulation by the action of the vanes. Through the sides of the box F and through insulating-gaskets H, when the material of the box is not a sufficiently good insulator, extend metallic terminal-plugs K K, with their end in the plane of the conducting segmental disk D and adjustable radially toward and from the edges of the segments. This or similar devices are employed to carry out the invention above referred to in the manner illustrated in Fig. 3. A in this figure represents any source of alternating current the potential of which is raised by a transformer, of which a is the primary and b the secondary. The ends of the secondary circuit S are connected to the terminal plugs K K of an apparatus similar to that of Figs. 1 and 2 and having segments rotating in synchronism with the alternations of the current source, preferably, as above described, by being mounted on the shaft of the generator when the conditions so permit. The plugs K K are then adjusted radially, so as to approach more or less the path of the outer edges of the segmental disk, and so that during the passage of each segment in front of a plug a spark will pass between them, which completes the secondary circuit S. The box or the support for the plugs K is adjusted angularly, so as to bring the plugs and segments into proximity at the desired instants with reference to any phase of the current-wave in the secondary circuit and fixed in position in any proper manner. To the plugs K K are also connected the terminals of a condenser or condensers L, so that at the instant of the rupture of the secondary circuit S by the cessation of the sparks the energy accumulated in such circuit will rush into and charge the condenser. A path of low self-induction and resistance, including a primary M of a few turns, is provided to receive the discharge of the condenser, when the circuit S is again completed by the passage of sparks, the discharge being manifested as a succession of extremely rapid impulses. The potential of these impulses may be raised by a secondary T, which constitutes the source of current for the working circuit or that containing the devices R for utilizing the current.

电路控制器被部分地安装在发电机的轴 C 的延伸部分上,并被部分地安装在该轴的框架上,或者安装在围绕该轴的静止套筒上。它的详细结构如下: D 是一个带有中心轮毂 D' 的金属板,该中心轮毂被焊接在或者被夹紧在轴 C 上。该板形成有在数量上对应于发电机输送的电流波的分段延伸部分。这些部分最好地被切掉,只留下边缘或框架,弯曲金属板 E 被固定到边缘或框架的一个半径上,它用作叶片,以在设备运行时保持空气循环。扇形盘和叶片包含在一个封闭的被绝缘的盒或箱 F 内,并被安装在发电机的轴承上,或以任何其他合适的方式安装,但能够围绕轴进行角度调整。为了便于这种调节,配备了带有一个旋钮或手柄的螺杆 F', 它被展示为穿过箱体的壁。后者可以通过该杆来调节,并且它当处于适当位置时,可以通过将杆向下拧入套筒中的或轴承中的凹陷来保持固定,如图 1 所示。空气通道 G G 设置在箱体的相对端,通过叶片的作用,空气通过该通道保持循环。当箱体 F 的材料不是足够好的绝缘体时,延伸金属终端插头 K K 穿过箱体 F 的侧面和绝缘垫圈 H,插头末端在导电扇形盘 D 的平面内,并且可在朝向和远离扇形盘 D 边缘的方向上径向地调节。这种或类似的装置被用来以图 3 所示的方式实施本发明。图中的 A 代表任何交流电源,其电位由变压器升高,其中 a 为初级, b 为次级。次级电路 S 的末端连接到类似于图 1 和 2 的一个装置的终端插头 K K,并且该装置具有与电流源的交替同步旋转的分段,优选地,如上所述,当条件允许时,是安装在发电机的轴上。然后径向调节插头 K K,以便或多或少地接近扇形盘的外周边缘的路径,并且使得在一个插头面前的每个分段的通过期间,一个火花将在它们之间通过,这个火花使次级电路 S 变得完整。插头 K 的盒子或支撑件可以进行角度调整,以便使插头和分段在相对于次级电路中电流波的任何相位的期望时刻能够接近,并以任何适当

的方式固定在适当的位置。一个或多个电容器 L 的终端也连接到插头 K K 上，从而在次级电路 S 由于火花停止而断裂的瞬间，在该电路中积累的能量将冲进电容器并对其充电。一个低自感和低电阻的路径，包括一个只有几匝的初级 M，被装配来接收电容器的放电，当电路 S 利用火花的通过再次完整时，放电表现为一连串的极快的脉冲。这些脉冲的电位可以由一个次级 T 升高，次级 T 构成工作电路的电流源或是构成包含了利用电流的设备 R 的工作电路的电流源。

By means of this apparatus effects of a novel and useful character are obtainable, but to still further increase the efficiency of the discharge or working current I have in some instances provided a means for further breaking up the individual sparks themselves. A device for this purpose is shown in Figs. 4 and 5. The box or case F in these figures is fixedly secured to the frame or bearing of the generator or motor which rotates the circuit-controller in synchronism with the alternating source. Within said box is a disk D, fixed to the shaft C, with projections d' extending from its edge parallel with the axis of the shaft. A similar disk D" on a spindle d, in face of the first, is mounted in a bearing in the end of the box F with a capability of rotary adjustment. The ends of the projections d' are deeply serrated or several pins or narrow projections placed side by side, as shown in Fig. 4, so that as those of the opposite disks pass each other a rapid succession of sparks will pass from the projections of one disk to those of the other.

通过这种装置方法，可以获得一个新颖和有用的效果，但是为了进一步提高放电或工作电流的效率，在某些情况下，我提供了进一步分解单个火花本身的方法。图 4 和图 5 展示了用于此目的的装置。这些图中的盒子或箱子 F 固定地安装在发电机或电动机的框架或轴承上，该发电机或电动机使电路控制器与交流电源同步旋转。在所述盒子内是一个固定在轴 C 上的圆盘 D，其突出部分 d' 从圆盘 D 的边缘沿着平行于轴的轴线方向延伸。心轴 d 上的一个类似圆盘 D" 面对第一个圆盘，利用一个旋转调节功能，该心轴被安装在盒子 F 端部的一个轴承中。如图 4 所示，突起 d' 的端部是深锯齿状的，或者是并排放置的几个销或窄突起，从而当面对面的圆盘的突起端部彼此经过时，快速的一连串的火花将从一个圆盘的突起传递到另一个圆盘的突起。

What I claim as my invention is—

我主张我的发明是—

1. The combination with a source of current, of a condenser adapted to be charged, thereby, a circuit into which the condenser discharges in a series of rapid impulses, and a circuit-controller for effecting the charging and discharge of said condenser, composed of conductors movable into and out of proximity with each other, whereby a spark may be maintained between them and the circuit closed thereby during determined intervals, as set forth.

1、一个组合，它包括一个电流源；一个电容器，它适于由此电源充电；一个电路，电容器的放电以一连串快速脉冲的形式进入其中；一个控制器用来实现所述电容器的充电和放电，它由可移动的能相互靠近和相互远离的多个导体构成，在这些导体之间维持一个火花，电路由此在确定的时间间隔期间闭合，如上所述。

2. The combination with a source of alternating current, of a condenser adapted to be charged thereby,

a circuit into which the condenser discharges in a series of rapid impulses, and a circuit-controller for effecting the charging and discharge of said condenser, composed of conductors movable into and out of proximity with each other in synchronism with the alternations of the source, as set forth.

2、一个组合，它包括一个交流电源；一个由此电源充电的电容器；一个电路，电容器的放电以一连串快速脉冲的形式进入其中；一个控制器用来实现所述电容器的充电和放电，它由可移动的能相互靠近和相互远离的多个导体构成，并与电源的交替同步，如上所述。

3. A circuit-controller for systems of the kind described, comprising in combination a pair of angularly-adjustable terminals and two or more rotating conductors mounted to pass in proximity to said terminals, as set forth.

3、一种用于所述类型系统的电路控制器，包括一对角度可调的终端和两个或更多旋转导体的，所述旋转导体被安装成经过所述终端的附近，如上所述。

4. A circuit-controller for systems on the kind described, comprising in combination two sets of conductors, one capable of rotation and the other of angular adjustment whereby they may be brought into and out of proximity to each other, at determinate points, and one or both being subdivided so as to present a group of conducting points, as set forth.

4、一种用于所述类型系统的电路控制器，包括构成组合的两组导体，一组能够旋转，另一组能够进行角度调节，由此它们可以在确定的点上彼此靠近或远离，并且一个或两个导体被细分以呈现一组导电点，如上所述。

NIKOLA TESLA.

尼古拉·特斯拉

Witnesses:

M. LAWSON DYER,
DRURY W. COOPER.

见证人:

M.劳森·戴尔、德鲁里·W·库珀。

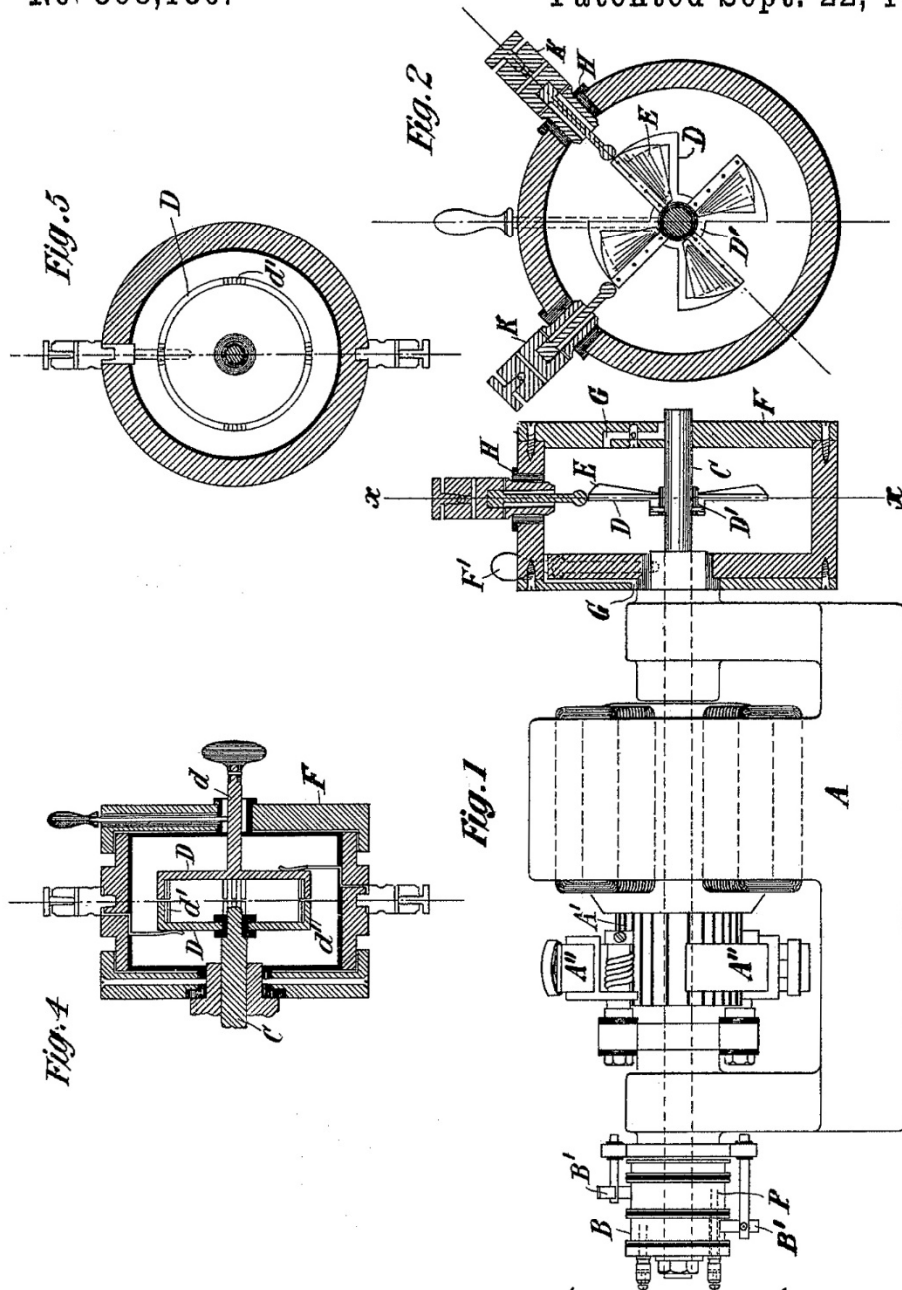
(No Model.)

2 Sheets—Sheet 1.

N. TESLA.
APPARATUS FOR PRODUCING ELECTRICAL CURRENTS OF
HIGH FREQUENCY.

No. 568,180.

Patented Sept. 22, 1896.



WITNESSES:

Edwin B. Hopkinson,
James M. Huntington

Nikola Tesla, INVENTOR

BY

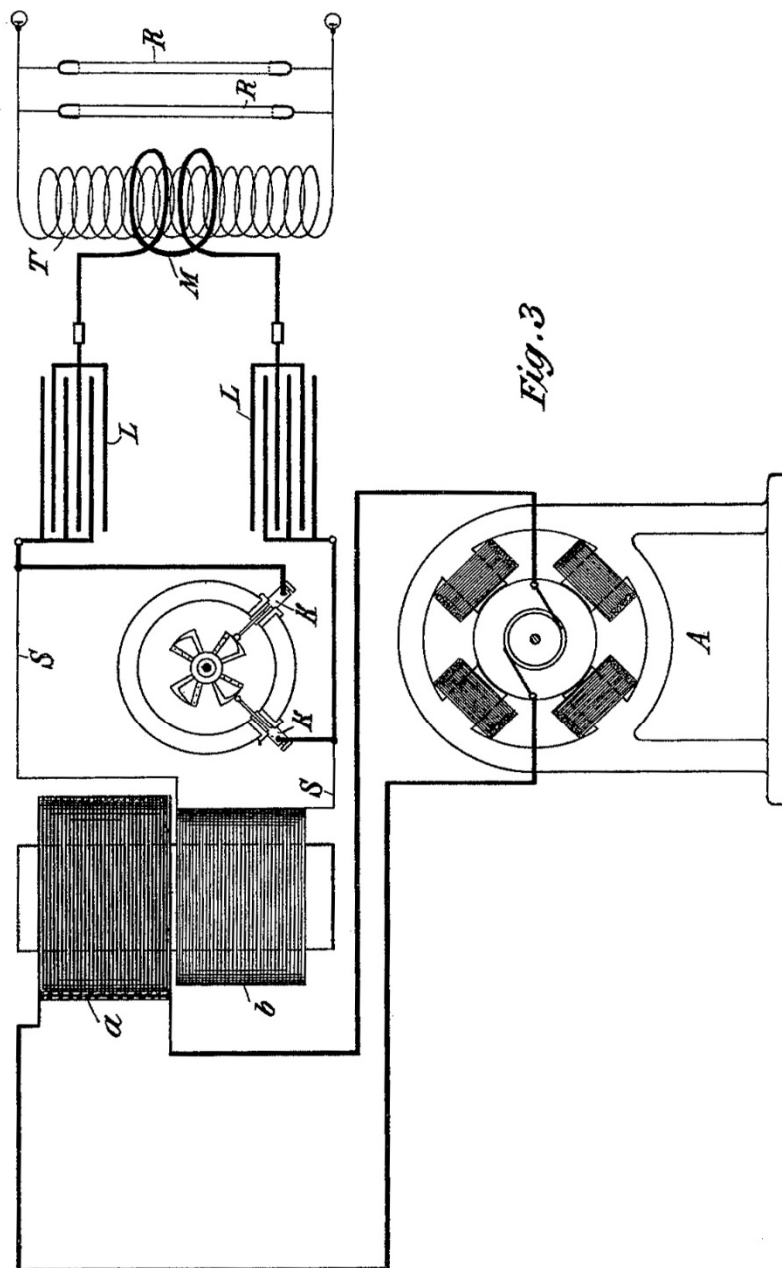
Hess, Curtis & Page, ATTORNEYS

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No. 568,180.

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WITNESSES:

Edwin B. Hopkinson.
Benjamin B. Foster.

Nikola Tesla

INVENTOR

BY

Herr, Curtis & Page, ATTORNEYS

APPARATUS FOR PRODUCING ELECTRIC CURRENTS OF HIGH FREQUENCY.

用于产生高频电流的装置

NIKOLA TESLA, OF NEW YORK, N. Y.

纽约州纽约市的尼古拉·特斯拉

SPECIFICATION forming part of Letters Patent No. 577,670, dated February 23, 1897.

Application filed September 3, 1896. Serial No. 604,723. (No model.)

该说明书形成了颁发于 1897 年 2 月 23 日编号为 577,670 的专利证书的一部分。

原始申请于 1896 年 9 月 3 日提交，序列号 604,723。(没有模型)

To all whom it may concern:

致所有有关人士:

Be it known that I, NIKOLA TESLA, a citizen of the United States, residing at New York, in the county and State of New York, have invented certain new and useful Improvements in Apparatus for Producing Electric Currents of High Frequency, of which the following is a specification, reference being had to the drawings accompanying and forming a part of the same.

众所周知，我、尼古拉·特斯拉，一位美国公民，居住在纽约州纽约郡纽约市，在用于产生高频电流的装置方面已经发明了某些新的和有用的改进，以下是该发明一个说明书，必须参考随附的图纸，它已形成了该说明书的一部分。

The apparatus for converting electric currents of ordinary character into those of high frequency, which I have heretofore shown and described in applications for Letters Patent, has usually comprised a condenser and a circuit-controller operated by a suitable motive device and acting to alternately charge the condenser from a suitable source of supply and discharge it through a circuit of such character as to render the discharge one of very high frequency. For many purposes it has been found advantageous to construct the circuit-controller with insulating and conducting segments of equal length, so that the condenser is connected with its discharge-circuit during one-half of the time only. It follows from this that the working circuit, or that in which the high-frequency currents are developed in form for practical application, receives such currents during only one-half the time.

用于将普通特性的电流转换成高频电流的装置，我在专利申请中已经展示和描述过，通常包括一个电容器和一个电路控制器，该电路控制器由一个合适的动力装置操作，并用于交替地从一个合适的电源给电容器充电，并通过一个具有这种特性的电路对电容器放电，从而使放电频率非常高。对于许多目的，已经发现用等长的绝缘分段和导电分段来构造电路控制器是

有优势的，这样电容器仅在一半的时间内与它的放电电路连接。由此得出结论，工作电路，或者那种用来产生高频电流并用于实际应用的电路，仅在一半的时间内接收这样的电流。

For certain purposes it is desirable for economical operation that there should be no cessation of the flow of such currents, and my present improvements have been devised with the object of increasing the output of a given apparatus by providing means by which, without material additions to or complication of such apparatus, high-frequency currents may be produced thereby continuously or without periods of rest.

出于某些目的，对于经济操作来说，不应该停止这种电流的流动是合乎需要的，并且我目前的改进已经被设计用于通过提供这样的工具来增加一个给定装置的输出，通过该装置，在没有给这种装置增加材料或使这种装置复杂化的情况下，高频电流可以连续地或没有间歇地产生。

Broadly stated, the improvement consists in the combination of two condensers with a circuit-controller of such character and so operated by a single motive device as to charge and discharge said condensers alternately, whereby one will be discharging while the other is being charged, and conversely.

概括地说，改进在于两个电容器与一个电路控制器的组合，该电路控制器具有这样的特征，并且由单个动力装置操作，以便交替地对所述电容器充电和放电，由此一个电容器将被放电，而另一个电容器将被充电，反之亦然。

In the drawings hereto annexed, Figure 1 is a diagrammatic illustration of the arrangement and circuit connections of the invention. Fig. 2 is a sectional view of a part of the commutator employed; and Fig. 3 is a diagram similar to that of Fig. 1, illustrative of a modified embodiment of the invention.

在附图中，图 1 是本发明的布置和电路连接的一个示意图。图 2 是所采用的换向器的一部分的剖视图；以及图 3 是类似于图 1 的示意图，展示了本发明的一个改进实施例。

Let A B designate the two conductors of any circuit from which the energy is derived that is to be converted into a current of high frequency.

让 A B 表示任何电路的两个导体，从这两个导体中汲取的能量将被转换成高频电流。

C is a circuit controller or commutator, a portion only for convenience being shown in the figures. It is designed to be rotated by any suitable motive device, of which, however, the shaft D only is shown, and its plan of construction is as follows:

C 是一个电路控制器或换向器，为了方便起见，图中仅展示了一部分。它被设计成由任何合适的动力装置来转动，然而，图中仅展示了轴 D，并且其构造方案如下：

The letters c c' designate two metal heads or castings with projecting portions d d', which, when the two heads are brought together and secured to a hub or shaft, intermesh, as shown in the drawings.

字母 c c' 表示两个带有突出部分 d d' 的金属头或铸件，当两个头被放在一起并固定到一个轮

穀或轴上时，它们相互啮合，如图所示。

The spaces between two adjacent projections or bars $d d'$ are equal in arc to the width of one of said bars and are filled in with blocks e , preferably of metal, insulated from the other conducting portions of the device. By the interposition of mica or other suitable insulating material the two heads or castings $c c'$ are insulated from each other. Upon the periphery of this commutator bear three brushes $G G' H$, the two former resting upon the continuous metallic portions of the two heads, respectively, the latter being in position to bear upon the projections $d d'$ and blocks e alternately.

两个相邻突起或条 $d d'$ 之间的空间在弧长上等于所述条的宽度，并且填充有块 e ，块 e 首选为金属的，与装置的其它导电部分绝缘。通过插入云母或其他合适的绝缘材料，两个头部或铸件 $c c'$ 彼此绝缘。在该换向器的外周上倚靠着三个电刷 $G G' H$ ，前两个电刷分别倚靠在两个头部的连续金属分段上，最后一个电刷位于在交替地倚靠突起 $d d'$ 和块 e 上的位置上。

In order that the brushes may be capable of carrying any current which the operation of the apparatus may demand, they are made of large cross-section, the brush H being approximately equal in width to one of the projections or segments $d d'$, or to the space between adjacent segments, so that in passing from one it comes into contact with the next.

为了使电刷能够承载操作设备可能需要的任何电流，它们由大截面制成，电刷 H 的宽度大约等于一个突起或分段 $d d'$ 的宽度，或者等于相邻分段之间的间距，因此在从一个分段经过时，它与下一个分段接触。

The brush H is connected to the main B through a primary coil K of low self-induction in inductive relation to a secondary L , which constitutes the ultimate source of the current of high frequency which the apparatus is designed to develop and which feeds a circuit containing vacuum tubes M , single terminal lamps M' , or other suitable devices. The brushes $G G'$ are connected with the main B through condensers $N N'$, respectively, and to the main A through self-induction or choking coils $O O'$, these latter being used in order that the inductive discharge of the accumulated energy therein may be taken advantage of in charging the condensers.

电刷 H 通过一个低自感的初级线圈 K 连接到干线 B 上，初级线圈 K 与一个次级线圈 L 呈感应关系，次级线圈 L 构成了高频电流的最终来源，该装置被设计用来产生高频电流，并向包含真空管 M 、单极灯 M' 或其它合适装置的电路供电。电刷 $G G'$ 分别通过电容器 $N N'$ 与干线 B 相连，并通过自感或扼流线圈 $O O'$ 与干线 A 相连，使用扼流线圈 $O O'$ 是为了在电容器充电时可以利用扼流线圈中积累的能量进行感应放电。

The operation of the apparatus thus described is as follows: By the rotation of the commutator C the brush H is caused to pass over the projections d , closing the circuits through the primary K and the two condensers alternately. These two circuits are so adjusted as to have the same capacity, self-induction, and resistance. When said brush is in electrical connection with any projection d' from the part c' the circuit is closed between mains A and B through coil O' , brush G' , brush H , and coil K . Energy is therefore accumulated in the coil O' . At the same time the condenser N' is short-circuited through the brush G' , brush H , and coil K , and discharges through this circuit the energy stored in it, the discharge being in the form of a series of impulses which induce in the secondary L corresponding

impulses of high potential. When brush H breaks the circuit through coil O', the high-potential discharge or "kick" from the latter rushes into and recharges the condenser N', but as soon as the brush H has passed over the intervening block e and reached the next segment d it closes the circuit through coil O and short-circuits the condenser N, so that high-frequency currents from either one or the other of the two condensers are flowing through the primary K practically without interruption. Thus without increasing the size or power of the motive device or complicating in any material degree the commutator these devices are made to perform double duty and the output of the apparatus as a whole greatly increased. In Fig. 3 I have illustrated a modified form of commutator for this apparatus, which comprises a disk E, of metal, but insulated from its shaft. The periphery of this disk is divided into conducting and insulated segments by the insertion therein of insulated metal blocks f. The circumferential width of these blocks is three times that of the conducting segments f'. A brush F bears upon a continuous metallic portion of the disk or upon a continuous ring in electrical connection with the segments f' and is connected with one terminal of the primary K. Brushes F' F'' bear upon the periphery of the disk E and are connected to the main B through the two condensers, respectively. These brushes are capable of angular adjustment, so that they may be set to bear upon the disk at any two desired points.

如此描述的设备的操作如下：利用换向器 C 的旋转，使得电刷 H 越过突起 d，交替地闭合通过初级 K 和两个电容器的电路。这两个电路经过调整，具有相同的电容、自感和电阻。当所述电刷与 c' 部分的任何突起 d' 电连接时，在电源 A 和 B 之间的电路通过线圈 O'、电刷 G'、电刷 H 和线圈 K 闭合。因此，能量积聚在线圈 O' 中。同时，电容器 N' 通过电刷 G'、电刷 H 和线圈 K 被短路，并通过这个电路释放存储在其中的能量，这种释放是以一系列脉冲的形式进行的，这些脉冲在次级线圈 L 中感应出相应的高电位脉冲。当电刷 H 通过线圈 O' 断开电路时，来自线圈 O' 的高电位放电或“反冲”进电容器 N' 并对其充电，但是一旦电刷 H 越过介入的块 e 并到达下一个分段 d 时，它就闭合通过线圈 O 的电路并使电容器 N 短路，因此来自两个电容器中的一个或另一个的高频电流实际上没有间断地流过初级 K。因此，在不增加动力装置的尺寸或功率或不在任何材料程度上使换向器复杂化的情况下，这些装置被制成执行双重任务，并且设备作为一个整体的输出大大增加。在图 3 中，我已经展示了用于该设备的换向器的一种改进形式，它包括一个金属盘 E，但是金属盘 E 与其轴绝缘。通过在其中插入被绝缘的金属块 f，该圆盘的外周被分成导电分段和绝缘分段，这些块的圆周宽度是导电分段 f' 的三倍。电刷 F 倚靠在圆盘的连续金属部分上，或者倚靠在与分段 f' 电连接的一个连续的圆环上，并与初级线圈 K 的一个终端相连。电刷 F' F'' 倚靠在磁盘 E 的外周，并分别通过两个电容器连接到干线 B。这些电刷能够进行角度调整，因此它们可以被设置成在任意两个所需的点上对盘施加压力。

From the explanation of the operation already given it is evident that when the two brushes F' F'' are set so that one leaves a segment f' at the instant that the other comes in contact with a segment f' the effect in charging and discharging the condensers is the same as in the previous instance. The capability of varying the relations of the brushes, however, which this form possesses has the advantage of permitting not only an alternate charging and discharge of the condensers, but their simultaneous charging and discharge in multiple arc, whereby the frequency of the current of discharge is reduced.

从已经给出的操作说明中可以明显看出，当两个电刷 F' F'' 被设置成使得其中一个电刷在另一个电刷与一个分段 f' 接触的瞬間离开一个分段 f' 时，电容器充电和放电的效果与前面的情况相同。然而，这种形式具有改变电刷关系的能力，其优点是不仅允许电容器交替地充电和

放电，而且允许它们在多弧连接中同时充电和放电，从而降低了放电电流的频率。

It is also evident that all phase differences in the charging and discharging of the condensers may in like manner be secured and the frequency varied within wide limits. Of course the same motor and circuit-controller might be made to charge more than two condensers in succession and to discharge them in the same order.

同样显而易见的是，电容器充电和放电的所有相位差可以以类似的方式得到保证，并且频率可以在很宽的范围内变化。当然，同一个电动机和电路控制器可以连续给两个以上的电容器充电，并以相同的顺序放电。

What I claim is—

我主张的是—

1. The combination with a source of electric energy, of a plurality of condensers and a discharge-circuit therefore, a motive device and a circuit-controller operated hereby and adapted to direct the energy of the source into the condensers and connect them with the discharge-circuit successively and in alternation, as set forth.

1、一个组合，它包括多个电容器、一个放电电路、一个动力装置、一个电路控制器和一个电源。该电路控制器在被上述动力装置操作并适于将电源的能量引导到电容器中，并将电容器相继地和交替地与放电电路连接，如上所述。

2. The combination with a source of electric energy, of a motive device, two condensers, a circuit-controller adapted to direct the energy of the source alternately into the said condensers, and a discharge-circuit through which, by the operation of said circuit-controller one condenser discharges while the other is being charged, as set forth.

2、一个组合，它包括一个动力装置、两个电容器、一个放电电路、一个电路控制器和一个电源。该电路控制器适于将电源的能量交替地引导到所述电容器中，并且一个放电电路通过所述电容器放电，一个电容器利用所述电路控制器的操作来放电，同时另一个电容器被充电，如上所述。

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APPARATUS FOR PRODUCING ELECTRIC CURRENTS OF HIGH FREQUENCY.

No. 577,670.

Patented Feb. 23, 1897.

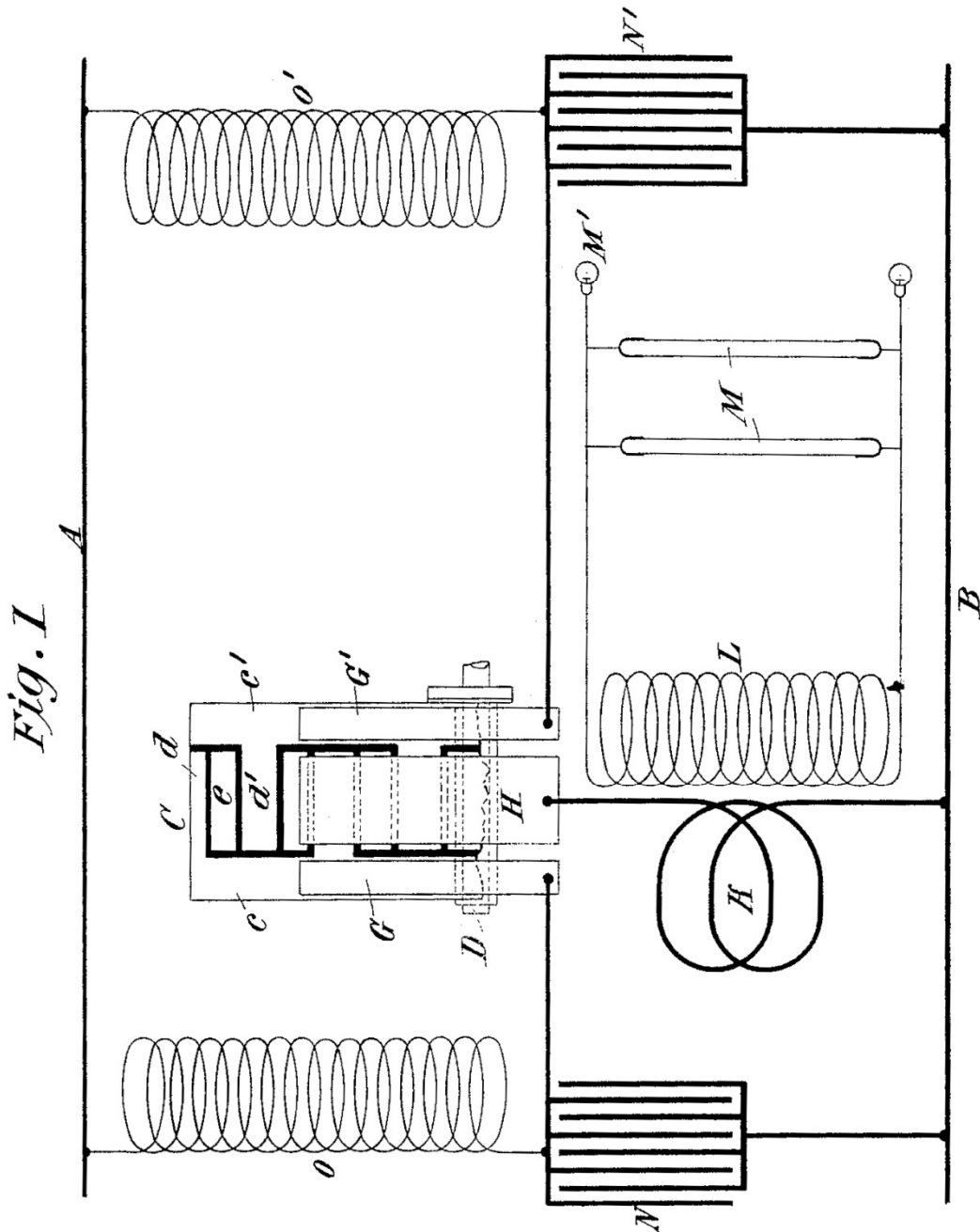
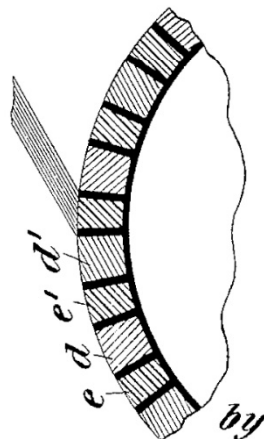


Fig. 2



Witnesses:
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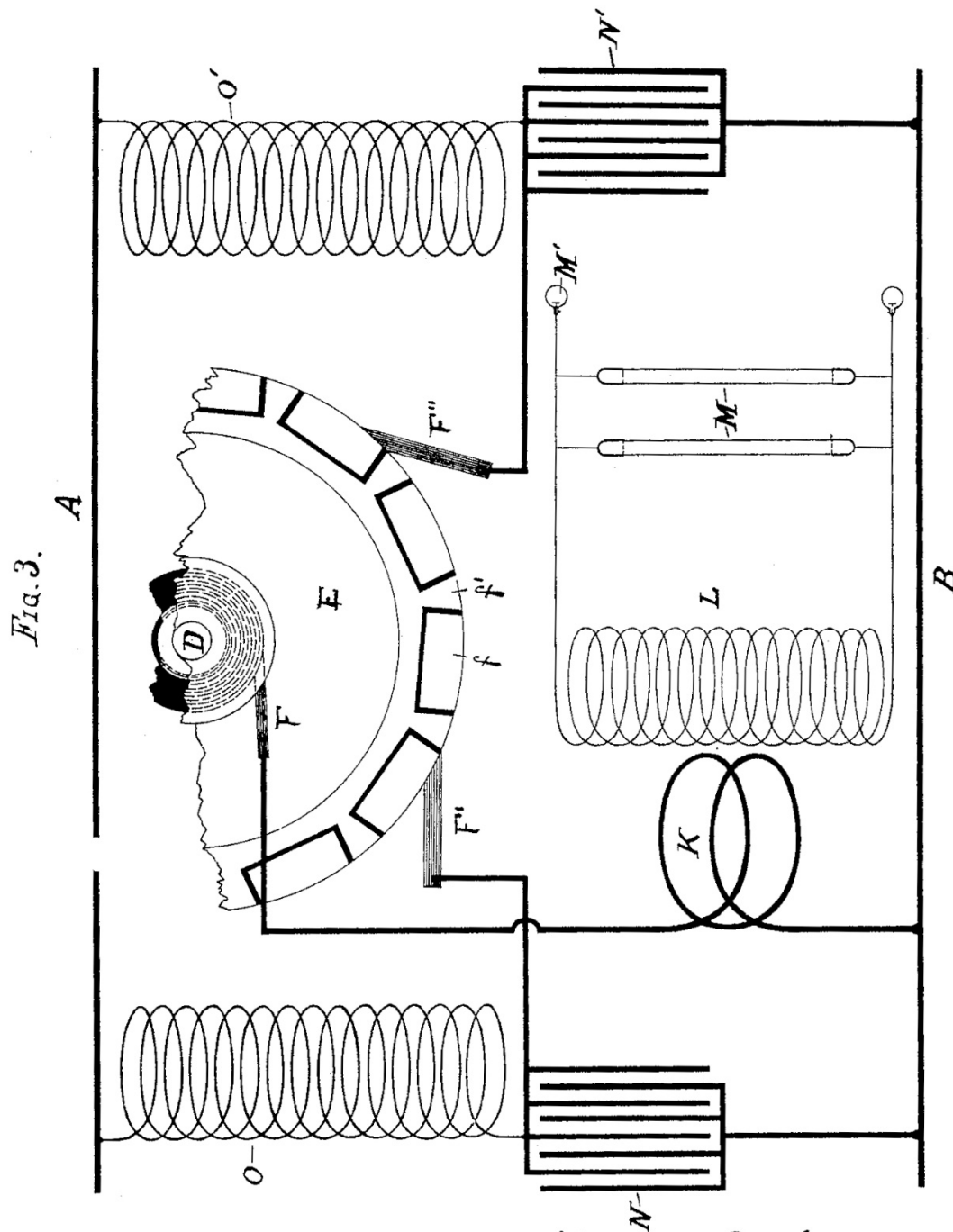
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APPARATUS FOR PRODUCING ELECTRIC CURRENTS OF HIGH FREQUENCY.

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WITNESSES

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APPARATUS FOR PRODUCING CURRENTS OF HIGH FREQUENCY.

用于产生高频电流的装置

NIKOLA TESLA, OF NEW YORK, N. Y.

纽约州纽约市的尼古拉·特斯拉

SPECIFICATION forming part of Letters Patent No. 583,953, dated June 8, 1897.

Application filed October 19, 1896. Serial No. 609,292. (No model.)

该说明书形成了颁发于 1897 年 6 月 8 日编号为 583,953 的专利证书的一部分。

申请于 1896 年 10 月 19 日提交，序列号为 609,292。(无模型)

To all whom it may concern:

致所有有关人士：

Be it known that I, NIKOLA TESLA, a citizen of the United States, residing at New York, in the county and State of New York, have invented certain new and useful Improvements in Apparatus for Producing Currents of High Frequency, of which the following is a specification, reference being had to the drawings accompanying and forming a part of the same.

我、尼古拉·特斯拉、一个美国公民，居住在纽约州纽约郡纽约市，在用于产生高频电流的装置方面发明了一些新的有用的改进，以下是该发明的一个说明，必须参考随附的图纸，它已形成了该说明书的一部分。

The invention upon which my present application is based is an improvement in apparatus for the conversion of electrical currents of ordinary character—such, for instance, as are obtainable from the mains of municipal electric light and power systems and either continuous or alternating—into currents of very high frequency and potential.

我的本申请所基于的发明是对那些用于将普通特性的电流(例如从市政电力照明和电力系统的干线获得的恒向电流或交流电流)转换成非常高的频率和电势的电流的装置的改进。

The improvement is applicable generally to apparatus of the kind heretofore invented by me and more particularly described in United States Letters Patent granted to me on September 22, 1896, No. 568,176, but in the description of the invention which follows the illustration is confined to a form of apparatus designed for converting a continuous or direct current into one of high frequency. In the several forms of apparatus for this purpose which I have devised and heretofore described I have employed a circuit of high self-induction connected with the mains from a suitable source of current and containing some form of circuit-controller for periodically interrupting it. Around the break or point of interruption I have arranged a condenser, into which the circuit discharges when interrupted, and this condenser is in

turn made to discharge through a circuit containing the primary of a transformer, and of such character that the condenser-discharge will be in the form of an extremely rapid succession of impulses.

这种改进一般适用于迄今为止由我发明的装置，更具体的在 1896 年 9 月 22 日授予我的美国专利证书第 568,176 号中有所描述，但在以下的说明中对本发明的描述仅局限于一种设计成将恒向电流或直流电流转换成高频电流的一种装置形式。在我已经设计和描述的用于此目的的几种形式的设备中，我已经采用了一种高自感电路，该电路与来自一个合适电流源的干线连接，并且包含了用于周期性中断它的某种形式的电路控制器。在断点或中断点周围，我布置了一个电容器，电路在中断时向该电容器放电，而该电容器又通过一个包含了变压器初级的电路放电，其特点是电容器放电将以极快的脉冲序列的形式进行。

Now in order to secure in an apparatus of this kind as high frequency as possible and the advantages resulting therefrom I subdivide the condenser necessary for storing the energy required into integral parts or provide independent condensers, and employ means for charging said condensers in multiple and discharging them in series through the primary of the transformer. To secure this result without unduly complicating the apparatus is a matter of very considerable difficulty, but I have accomplished it by means of the apparatus which I shall now proceed to describe by reference to the drawings.

现在，为了在这种类型的设备中确保尽可能高的频率以及由此产生的优点，我将存储所需能量所需的电容器进行了细分，使之成为不可缺少的部件，或者配备独立的电容器，并且采用能对所述电容器多次充电并且通过变压器的初级连续放电的工具。为了确保这一结果而不使装置过度复杂化是一件非常困难的事情，但是我已经通过装置完成了这一点，现在我将参照附图对该装置进行描述。

Figure 1 is a side elevation of the apparatus which I employ, and Fig. 2 is a diagram of the circuit connections.

图 1 是我使用的装置的一张侧视图，图 2 是一张电路连接示意图。

Referring to Fig. 1, A is a box or case containing the condensers, of which the terminals are a a b b, respectively. On this case is mounted a small electromagnetic motor B, by the shaft of which is operated the circuit-controller C. Upon the said controller bear brushes, as shown at D D' D" D'''.

参考图 1，A 是容纳电容器的盒子或箱子，电容器的终端分别是 a a b b。在这种情况下，安装了一个小的电磁电动机 B，通过其轴来操作电路控制器 C。倚靠在所述控制器轴上的是电刷，如图所示是 D D' D" D'''。

F F are self-induction coils placed beside the motor. Above these is the transformer, composed, essentially, of a primary G and a secondary H. These devices are intended to be enclosed in a suitable box or case, and may be very greatly modified in construction and relative arrangement. The circuit-controller, however, should conform in general principle of construction to that hereinafter described in so far as may be necessary to secure the operation pointed out.

F F 是放置在电动机旁边的自感线圈。在这些之上是变压器，基本上由初级 G 和次级 H 组成。这些设备旨在封装在合适的盒子或箱子中，并且可以在结构上和相对布置上进行非常大

的修改。然而，电路控制器的一般构造原理应符合下文所述的原理，以确保所指出的操作。

Referring now to Fig. 2, L L designate the mains from a suitable source of supply, between which a circuit is formed, including the self-induction coils F F and the circuit-controller C. A switch d may be employed to bring either or both of the coils F F into this circuit, as may be desired.

现在参考图 2，L L 表示来自合适一个电源的干线，一个电路在它们之间形成，该电路包括自感线圈 F F 和电路控制器 C。根据需要，可以使用一个开关 d 将线圈 F F 中的一个或两个引入该电路。

The circuit-controller is built up of insulated plates or segments, upon which the positive and negative brushes bear, and these plates may be considered as belonging to three sets or classes, first, the plates m for what may be considered as the positive brushes D D' in one row, electrically connected together, and the corresponding plates n for what may similarly be considered as the negative brushes E E' in the other row; second, the plates o, which lie in both rows, and hence are conveniently made in single pieces extending across the controller, and, third, the idle or spacing plates p, which are interposed in each row between the other two sets. The angle between adjacent plates of the same set is equal to the angle of displacement between adjacent brushes of the same sign, and obviously there may be two or more of each. The brush D of one set is connected with one main through the coils F, and each one of the brushes of the same set is connected to one of the terminals of the condensers M N, respectively. Similarly the brush E of the other set of brushes is connected to the opposite main and each of the brushes of said set to the opposite condenser terminals through the primary or strands of a primary G. In the diagram, Fig. 2, I have shown but two brushes in each set and two condensers, but more than this number may be used, the same plan of connections shown and described being followed out.

电路控制器由绝缘板或绝缘分段构成，正负电刷倚靠其上，这些板可被认为属于三组或三类，第一组，板 m 可被认为是一排中的正电刷 D D'，它们电连接在一起，相应的板 n 可被认为是另一排中的负电刷 E E'；第二组，位于两排之间的板 o，因此可以方便地制成多个单件，延伸穿过控制器，第三组，空转板或间隔板 p，插入在其它两组板之间的每排中。同一组的相邻板之间的角度等于相同符号的相邻刷之间的位移角度，显然每个组可以有两个或更多个角度。一组电刷 D 通过线圈 F 与一条干线相连，同一组的每个电刷分别与电容器 M N 的终端中的一个相连。类似地，另一组电刷中的电刷 E 连接到相对的干线上，并且所述组的每个电刷通过初级或一个初级 G 的线股连接到相对的电容器终端上。在图 2 中，我只展示了每组中的两个电刷和两个电容器，但是它们可以使用更多的数量，遵循所示和所述的相同的连接方案。

In the position of the parts shown in Fig. 2, in which two positive and two negative brushes are shown, the brushes are bearing on plates m m and n n. Consequently the circuit through the coils F F is through the condensers in multiple, and, assuming that energy has been stored in said coils, the condensers will thus be charged. If now by the movement of the controller plates or brushes the latter are shifted across the idle or spacing plates p onto the long or cross-connected plates o two results follow: The mains are short-circuited through the coils F F, which therefore store energy, while the condensers are connected in series through the primary coil or coils G. These actions are repeated by the further movement of the controller, the condensers being charged in parallel when the brushes are on plates m n and discharged in series when the brushes pass onto plates o. The motor may be run by an independent

source or by current derived from the mains, and the apparatus may be employed to supply current for any suitable devices S T, connected with the secondary coil H.

在图 2 所示的部件的位置,展示出了两个正电刷和两个负电刷,电刷倚靠在板 m m 和 n n 上因此,通过线圈 F F 的电路通过多个电容器,并且假设能量已经存储在所述线圈中,电容器将因此被充电。如果现在通过控制器板或电刷的移动,后者被移动穿过空闲板或间隔板 p 到长的或交叉连接的板 o 上,则产生两个结果:干线通过线圈 F F 短路,线圈 F F 因此储存能量,而电容器通过初级线圈或线圈 G 串联。这些动作通过控制器的进一步运动被重复,当电刷在板 m n 上时,电容器并联充电,而当电刷经过板 o 上时,电容器串联放电。电动机可以由一个独立的电源或由来自干线的电流驱动,并且该装置可以用于为连接次级线圈 H 的任何合适的装置 S T 提供电流。

As stated above, the specific construction of the circuit-controller may be very greatly varied without departure from the invention. In the drawings the plates are assumed to be associated in the form of a cylinder which revolves with respect to brushes bearing on its periphery; but it will be understood that this is merely a typical illustration of any form of terminals or contacts and conductors, whether rotary or reciprocating, which constitute a circuit-controller capable of effecting the same result.

如上所述,在不脱离本发明的情况下,电路控制器的具体结构可以有很大的变化。在附图中,假设板以圆柱的形式相连接,该圆柱相对于倚靠在它外围的电刷旋转;但是应该理解,这仅仅是任何形式的终端或触点和导体的典型说明,无论是旋转的还是往复的,它们构成能够实现相同结果的电路控制器。

The advantages of resulting from the subdivision of the condenser or the employment of a plurality of condensers are mainly that a high frequency is obtainable in apparatus of any size; that the current of discharge through the sliding contacts is greatly reduced and injury to such contacts thereby avoided and a great saving in wire in the secondary effected.

细分电容器或使用多个电容器的优点主要在于,在任何尺寸的设备中都可以获得高频率;通过滑动触点的放电电流大大减小,从而避免了对这种触点的伤害,并且大大节省了次级线圈中的导线。

What I claim is—

我主张的是—

1. In an apparatus of the kind described, the combination with a set of contacts, one of which is adapted for connection with one of the mains from a source of current, and each of which is connected to one of the terminals of a series of condensers, and a second set of contacts similarly connected to the opposite main and condenser terminals, respectively, of electrically-connected plates or segments upon which the contacts of the first set bear, similarly-connected plates upon which the contacts of the second set bear, and isolated plates common to the two sets of contacts, the said plates being arranged in the manner described, whereby the condensers will be alternately charged in multiple and discharged in series, as set forth.

1、在所述类型的设备中，存在一个组合，它包括一组触点，其中一个触点适于与来自一个电源的干线之一连接，并且每个触点连接到一系列电容器的终端之一上；另一组触点类似地分别连接到相对的干线和电容器终端上；还包括第一组触点所倚靠的被电连接的板或分段；还有第二组触点所依靠的被类似地电连接的板或分段；以及两组触点共用的分隔板，所述板以所述方式布置，由此电容器将交替地并联充电和串联放电，如上所述。

2. In an apparatus of the kind described, the combination with a set of positive brushes, one of which is adapted for connection with one of the mains from a source of current, and each of which is connected to one of the terminals of a series of condensers, and negative brushes similarly connected to the opposite main and condenser terminals, respectively, of a cylinder composed of electrically-connected segments upon which the positive brushes only bear, similarly-connected segments upon which the negative brushes only bear, and isolated plates upon which both sets of brushes simultaneously bear, the said plates being arranged in the manner described, whereby the condensers will be alternately charged in multiple and discharged in series, as set forth.

2、在所述类型的设备中，存在一个组合，它包括一组正电刷，其中一个正电刷适合于与来自一个电源的干线之一连接，并且每个正电刷连接到一系列电容器终端之一上；还包括一组负电刷，它们类似地分别连接到相对的干线和电容器终端上；还包括一个圆柱，它由正电刷所倚靠的被电气连接的分段所构成；还有负电刷所倚靠的被类似地电连接的分段；以及两组电刷所共用的分隔板，所述板以所述方式布置，由此电容器将交替地并联充电和串联放电，如上所述。

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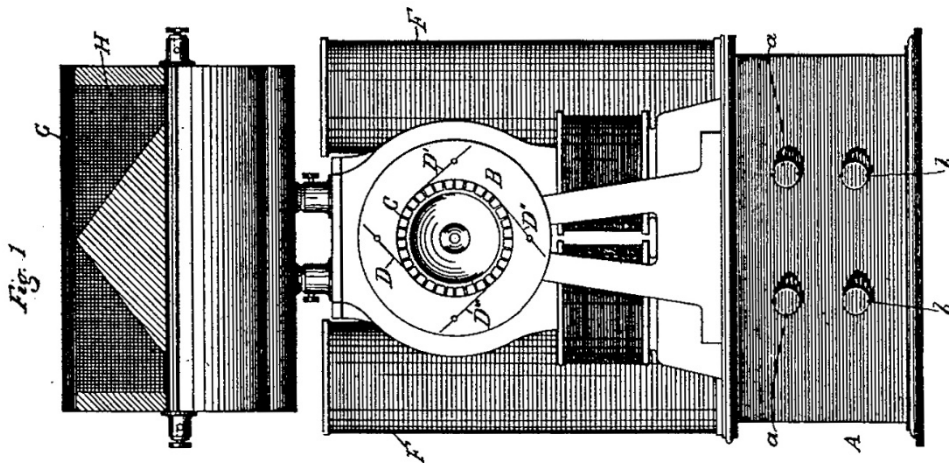
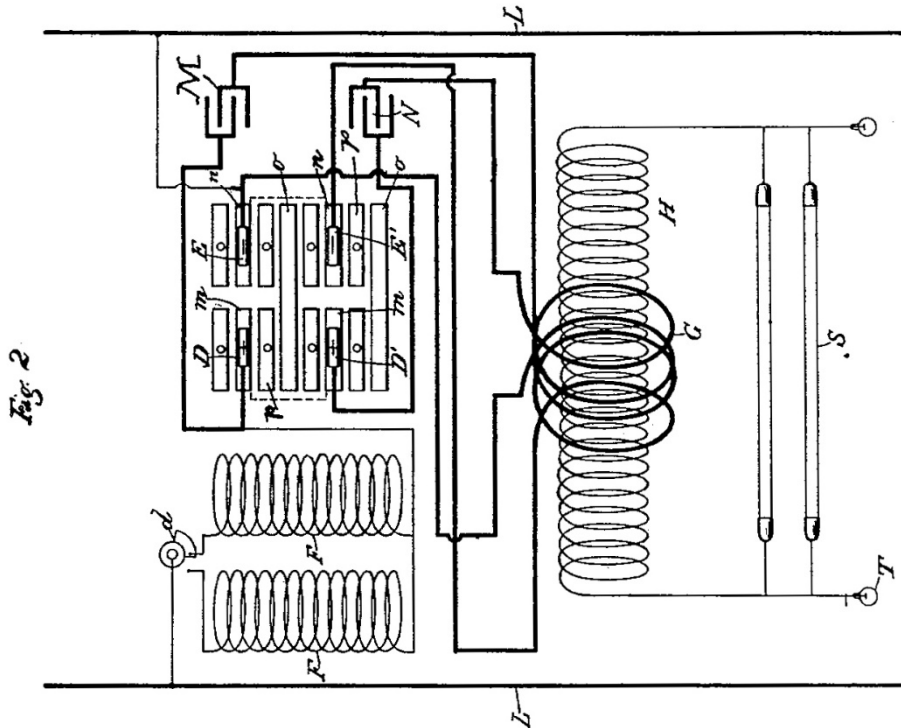
(No Model.)

N. TESLA.

APPARATUS FOR PRODUCING CURRENTS OF HIGH FREQUENCY.

No. 583,953.

Patented June 8, 1897.



WITNESSES

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IMPROVEMENTS RELATING TO THE
PRODUCTION, REGULATION, AND
UTILIZATION OF ELECTRIC CURRENTS
OF HIGH FREQUENCY, AND TO
APPARATUS THEREFOR

与高频电流的产生、调节和利用有关的改
进及其装置

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1896 年 9 月 22 日申请-1896 年 11 月 21 日被接受

COMPLETE SPECIFICATION.
完整说明

Communicated from abroad by Nikola Tesla, of 46 East Houston Street,
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居住在美国纽约市曼哈顿区东休斯顿街 46 号的
电气技师尼古拉·特斯拉发来的通讯。

I, Henry Harris Lake, of the Firm of Haseltine, Lake & Co., Patent Agents, 45 Southampton Buildings,
in the County of Middlesex, do hereby declare the nature of this invention and in what manner the
same is to be performed, to be particularly described and ascertained in and by the following statement:-

本人，亨利·哈里斯·雷克，来自英国密得塞斯郡南安普顿大厦 45 号哈兹尔廷（雷克）专
利代理公司，特此声明本发明的性质以及以何种方式执行本发明，并在以下声明中具体说明
和确定：

This invention, subject of the present application, is embodied in certain improvements in methods of
and apparatus for producing, regulating and utilizing electric currents of high frequency heretofore
invented by Nikola Tesla, and described in British Letters Patent No. 8575, dated May 19, 1889. The
method and apparatus referred to in said patent were devised for the purpose of converting, supplying
and utilizing electrical energy in a form suited for the production of certain novel electrical phenomena
which require currents of high potential and a higher frequency than can readily or even possibly, be

developed by generators of the ordinary types or by such mechanical appliances as were theretofore known. The invention referred to was based upon the principle of charging a condenser or a circuit possessing capacity and discharging the same, generally through the primary of a transformer, the secondary of which constituted the source of working current, and under such conditions as to yield a vibratory or rapidly intermittent discharge current.

作为本申请主题，本发明体现在对用于产生、调节和利用高频电流的方法和装置的某些改进中，这些改进迄今为止由尼古拉·特斯拉发明，并在 1889 年 5 月 19 日的英国专利证书第 8575 号中描述。所述专利中提到的方法和装置是为了转换、供应和利用电能的目的而设计的，其形式适合于产生某些新的电现象，这些电现象需要高电位和一个更高频率的电流，这些电流可以容易地或甚至可能由普通类型的发电机或由迄今已知的机械设备产生。所提到的发明是基于对一个电容器或一个具有电容量的电路进行充电和放电的原理，通常通过一个变压器的初级，变压器的次级构成工作电流源，并且在这样的条件下产生振动或快速间歇放电电流。

The present invention, while aiming to simplify and render more efficient the apparatus heretofore used, has for its object, primarily, to provide a means for converting such currents as are generally and most readily obtainable from the mains of ordinary systems of municipal distribution, into currents of the special character referred to, and to regulate or control, and utilize such currents in a simple, economical and efficient manner. The improvements are illustrated herein in forms of apparatus adapted for use with existing circuits or systems, and which while constructed and operating on the same general principles are modified only as may be required by a direct or an alternating source of supply.

本发明虽然旨在简化和提高迄今为止使用的设备的效率，但其目的主要是提供一种工具将通常且最容易从普通市政配电系统的干线获得的电流转换为所述特殊特性的电流，并以简单、经济且有效的方式调节或控制和利用这种电流。在此以适合与现有电路或系统一起使用的设备的形式来说明这些改进，这些装置虽然是根据相同的一般原理构造和操作的，但仅根据需要一个直流或一个交流电源进行修改。

The apparatus by which the present improvements are carried out may be described in general terms as comprising a circuit from a given source of supply, in which is included or with which is connected any suitable device for making and breaking such circuit in the manner desired, a condenser arranged so as to be periodically charged by the said circuit through the instrumentality of the circuit controller, and a circuit, through which the condenser discharges, of such character that the discharge will take place in a series of rapidly recurring or intermittent impulses.

实施本改进的设备可以概括地描述为有一个来自给定电源的电路组成，该电路包括或连接有用于以期望的方式接通和断开这种电路的任何合适的装置、布置成通过电路控制器的工具由所述电路周期性地充电的一个电容器、以及电容器的放电所通过的电路，该电路的特征在于放电将以一系列快速重复或间歇的脉冲发生。

In the drawings which illustrate the invention,

在说明本发明的附图中，

Fig. 1 is a diagram of circuits and apparatus employed with a source of direct currents. Figs. 2 and 3 are modifications of the same.

图 1 是与直流电源一起使用的电路和装置的示意图。图 2 和图 3 是对其进行的改进。

Figs. 4, 5 and 6 illustrate the apparatus and circuit connections employed with a source of alternating current. Figs. 7, 8, 9, 10 are similar views illustrating the method of and apparatus for regulating the system.

图 4、5 和 6 展示了使用交流电源的装置和电路连接。图 7、8、9、10 是说明用于调节系统的方法和装置的类似视图。

Figs. 11, 12, 13, 14 and 15 are views illustrating a form of circuit controller for use with the system and the manner of connecting up and using the same.

图 11、12、13、14 和 15 是展示用于该系统的电路控制器的一个形式以及连接和使用该电路控制器的方式的视图。

When the apparatus is to be employed for the purpose of converting a direct current of comparatively low potential into one of high frequency, a device in the nature of a choking coil is interposed in the circuit, in order that advantage may be taken of the discharge of high electro-motive force, which is manifested at each break of such circuit for charging a condenser.

当该装置用于将较低电位的直流电转换成高频直流电时,在电路中插入一个具有扼流线圈性质的装置,以便可以利用高电动势放电的优势,这在用于给电容器充电的这种电路的每次断开时表现出来。

It will be apparent from a consideration of the conditions involved, that were the condenser to be directly charged by the current from the source and then discharged into its local or discharging circuit, a very large capacity would ordinarily be required, but by the introduction into the charging circuit of a high self induction the current of high electro-motive force which is induced at each break of said circuit, furnishes the proper current for charging the condenser, which may, therefore, be small and inexpensive.

考虑到所涉及的条件,显而易见的是,如果电容器由来自电源的电流直接充电,然后放电到它的局部电路或放电电路中,通常需要非常大的电容量,但是通过将一个高自感引入充电电路,在所述电路的每次断开时会感应出一个高电动势的电流,该电流提供了用于对电容器充电的适当电流,因此电容器可以是小容量且便宜的。

Figures 1 and 2 illustrate that part of the improvement which relates to the conversion of direct or continuous current. Referring to said figures, A designates any source of direct current. In any branch of the circuit from said source, such, for example, as would be formed by the conductors A' A", and the conductors K K are placed self induction or choking coils B B and any proper form of circuit controlling device as C. This device in the present instance is shown as an ordinary metallic disk or cylinder with teeth or separated segments D D, E E, of which one or more pairs as E E, diametrically opposite, are integral or in electrical contact with the body of the cylinder, so that when

the controller is in the position in which the two brushes F, F', bear upon two of said segments E E, the circuit through the choking coils B B will be closed. The segments D, D, are insulated, and while shown in the drawings as of substantially the same length of arc as the segments E E, this latter relation may be varied at will to regulate the periods of charging and discharging.

图 1 和图 2 展示了涉及直流或恒向电流转换的改进部分。参考所述附图，A 表示任何直流电源。在来自所述电源（例如由来自干线 A' A' 的导体 A'' A'' 所形成电源）的电路的任何分支中，导体 K K 被放置了自感或扼流线圈 B B 以及任何适当形式的电路控制装置，如 C。在本实例中，该装置被展示为普通的金属盘或圆柱，具有齿或分开的分段 D D 和 E E，其中一对或多对（如 E E）在径向上是相对的，并与圆柱主体是一体的或电气接触，从而当控制器处于两个电刷 F F' 所倚靠的位于两个所述分段 E E 上的位置时，通过扼流线圈 B B 的电路将闭合。分段 D D 是被绝缘的，虽然在图中展示出与分段 E E 基本上相同的圆弧长度，但是后一种关系可以随意改变以调节充电和放电的周期。

The controller is designed to be rotated by any proper device, such for example, as an electro-magnetic motor, as shown in Figure 2, receiving current either from the main source or elsewhere.

控制器被设计成由任何合适的装置旋转，例如，如图 2 所示的一个电磁电动机，它从主电源或其它地方接收电流。

Around the controller C or in general having its terminals connected with the circuit on opposite sides of the point of interruption, is a condenser H, or a circuit of suitable capacity, and in series with the latter the primary K of a transformer, the secondary L of which constitutes the source of the currents of high frequency. L' indicates the circuit from the secondary and may be regarded as the working circuit.

在控制器 C 的周围，或者是一个电容器 H 的终端与电路在中断点的相对侧连接，或者是一个具有合适容量的电路，一个变压器的初级 K 与后者串联，该变压器的次级 L 构成高频电流源。L' 表示来自次级的电路，可视为工作电路。

It will be observed that since the self induction of the circuit through which the condenser discharges, as well as the capacity of the condenser itself, may be given practically any desired value, the frequency of the discharge current may be adjusted at will.

将会观察到，由于电容器的放电所要通过的电路的自感应以及电容器本身的电容量，实际上可以给定任何期望值，所以放电电流的频率可以随意调节。

In the operation of this apparatus the controller closes the charging circuit and then interrupts the same. When the break occurs the accumulated energy in the said circuit charges the condenser. Then while the charging circuit is again completed, the condenser discharges through the primary K, by a succession of rapid impulses. These operations are maintained by the action of the controller.

在该设备的操作中，控制器闭合充电电路，然后中断充电电路。当断路发生时，所述电路中积累的能量对电容器充电。然后，当充电电路再次完成时，电容器通过一系列快速脉冲通过初级 K 放电。这些操作由控制器的动作来维持。

A more convenient and simplified arrangement of the apparatus is shown in Figure 2. In this case the small motor G which drives the controller has its field coils M M' in derivation to the main circuit, and the controller C and condenser H, are in parallel in the field circuit between the two coils. In such case the field coils M M' take the place of the choking coils B.

图 2 展示了该设备的更方便和简化后的布置。在这种情况下，驱动控制器的小电动机 G 的励磁线圈 M M' 与干线电路间接连接（通过线圈进行连接），控制器 C 和电容器 H 并联在两个线圈之间的励磁电路中。在这种情况下，励磁线圈 M M' 代替了扼流线圈 B。

In this arrangement, and in fact, generally, it is preferable to use two condensers or a condenser in two parts, and to arrange the primary coil of the transformer between them. The interruption of the field circuit of the motor should be so rapid as to permit only a partial demagnetization of the cores; these latter, moreover, should in this specific arrangement, be laminated.

在这种布置中，事实上，通常优选的是使用两个电容器或者一个电容器分成两部分，并且将变压器的初级线圈布置在它们之间。电动机的励磁电路的中断应足够迅速，以便仅允许铁芯部分退磁；此外，在这种特定的布置中，后者应该是叠片的。

In lieu of connecting the field coils of the motor only with the charging circuit to raise the self induction therein, the motor may be connected in other ways, that is to say, its armature only may be connected with the circuit, or its field and armature coils may be in series and both connected with such circuit. This latter arrangement is illustrated in Figure 3, in which a terminal of the circuit A" is connected to one of the binding posts of the motor from which the circuit is led through one field coil M, the brushes and commutator C' and the other field coil M', and thence to a brush F which rests upon the controller disk or cylinder C. The other terminal of the circuit connects with a second brush F' bearing on the controller, so that the current which passes through and operates the motor is periodically interrupted.

除了将电动机的励磁线圈仅与充电电路连接以提高其中的自感外，还可以将电动机以其他方式连接，即仅将其电枢与电路连接，或者将其励磁线圈和电枢线圈进行串联并且都与这种电路相连。后一种布置如图 3 所示，其中电路 A" 的一个终端连接到电动机的接线柱之一上，电路从该接线柱通过一个励磁线圈 M、电刷和换向器 C' 以及另一个励磁线圈 M'，并由此到达倚靠在控制器盘或圆柱 C 上的一个电刷 F。电路的另一个终端与倚靠在控制器上的另一个电刷 F' 连接，使得通过电动机并操作电动机的电流被周期性地中断。

As an illustration of the various uses to which the apparatus may be put, the secondary L is shown in this figure as connected to two plates P, P, of any suitable character between which a current of air is maintained by a fan on the shaft of the motor G, for developing ozone or for similar purposes.

为了说明该装置的各种用途，在该图中展示了次级线圈 L 连接到两个板 P P 上，这两个板具有任何适合的特征，在这两个板 P P 之间通过电动机 G 轴上的风扇维持气流，用于产生臭氧或用于类似目的。

When the potential of the source of current periodically rises and falls, whether with reversals or not is immaterial, it is essential to economical operation that the intervals of interruption of the charging circuit should bear a definite time relation to the period of the current, in order that the effective

potential of the impulses charging the condenser may be as high as possible. In case, therefore, an alternating or equivalent electromotive force be employed as the source of supply, a circuit controller is used which will interrupt the charging circuit at instants predetermined with reference to the variations of potential therein.

当电流源的电位周期性地上升和下降时，无论有无反转都是无关紧要的，为了使电容器充电的脉冲的有效电位尽可能高，充电电路的中断间隔应与电流周期有确定的时间关系，这对经济地运行是至关重要的。因此，在采用一个交流的或等效的电动势作为电源的情况下，使用电路控制器，该电路控制器将在参考充电电路中电势变化的预定时刻中断充电电路。

A convenient, and probably the most practicable means for accomplishing this is a synchronous motor connected with the source of supply and operating a circuit controller which first interrupts the charging current at or about the instant of highest intensity of each wave and then permits the condenser to discharge the energy stored in it, through its appropriate circuit. Such apparatus, which may be regarded as typical of the means for accomplishing this purpose, is illustrated in Figures 4, 5 and 6.

实现这一点的，一个方便的，并且有可能最可行的工具是一个与电源连接的同步电机，并且运行一个电路控制器，该电路控制器首先在每个波的最高强度时刻或其附近中断充电电流，然后允许电容器通过其适当的电路释放存储在其中的能量。在图 4、5 和 6 中展示了这种装置，它可以被认为是实现这一目的的典型工具。

In Fig. 4, A" A" are the conductors taken from the mains of any alternating current generator A, and for raising the potential of such current a transformer is employed represented by the primary B and secondary B'.

在图 4 中，A" A" 是从任何交流发电机 A 的干线引出的导线，为了提高这种电流的电势，采用了一个变压器，其初级和次级分别用 B 和 B' 表示。

The circuit of the secondary includes the energizing coils of a synchronous motor G, and a circuit controller C fixed to the shaft of the motor.

次级电路包括一个同步电动机 G 的励磁线圈和固定在电机轴上的一个电路控制器 C。

An insulating arm O, stationary with respect to the motor shaft and adjustable with reference to the poles of the fixed magnets, carries two brushes F F' which bear upon the periphery of the disk C. With the parts thus arranged, the secondary circuit is completed through the coils of the motor whenever the two brushes rest upon the uninsulated segments of the disk, and interrupted through the motor at other times.

一个绝缘臂 O 相对于电动机轴是静止的，并可根据固定磁铁的磁极进行调节，该绝缘臂 O 带有两个电刷 FF'，这两个电刷倚靠在圆盘 C 的外周上。利用这样布置的部件，每当两个电刷倚靠在圆盘的未被绝缘的部分上时，次级电路通过电动机的线圈来完成，而在其它时候则通过电动机断开。

Such a motor, if properly constructed, in well understood ways, maintains very exact synchronism with

the alternations of the source, and the arm O may, therefore, be adjusted to interrupt the current at any determined point of its waves. By the proper relations of insulated and conducting segments, and the motor poles, the current may be interrupted twice in each complete wave at or about the points of highest intensity.

这种电动机，如果以易于理解的方式适当地构造，可以保持与电源的交替非常精确的同步，因此，臂 O 可以被调整到在其波的任何确定的点中断电流。通过被绝缘分段和导电分段以及和电动机磁极之间的适当关系，电流可以在每个完整的波中在最高强度点处或附近被中断两次。

In order that the energy stored in the motor circuit may be utilized at each break to charge the condenser H, the terminals of the latter are connected to the two brushes F F' or to points of the circuit adjacent thereto, so that when the circuit through the motor is interrupted the terminals of the motor circuit will be connected with the condenser. The discharge of the condenser takes place through the primary K, the circuit of which is completed simultaneously with the motor circuit and interrupted while the motor circuit is broken and the condenser being charged. The secondary impulses of high potential and great frequency are available for the operation of vacuum tubes P, single terminal lamps R, and other novel and useful purposes.

为了在每次断电时可以利用存储在电动机电路中的能量给电容器 H 充电，电容器 H 的终端连接到两个电刷 F F' 或与其相邻的电路点上，因此当通过电动机的电路被中断时，电动机电路的终端将与电容器连接。电容器的放电通过初级线圈 K 进行，初级线圈 K 的电路与电机电路同时完成，并当电动机电路断开且电容器充电时，初级线圈 K 的电路被中断。高电势和高频率的次级脉冲可用于操作真空管 P、单极灯 R 和其它新颖有用的目的。

It is obvious that the supply current need not be alternating, provided it be converted or transformed into an alternating current, before reaching the controller. For example, the present improvements are applicable to various forms of rotary transformers as is illustrated in Figs. 5 and 6.

很明显，只要在到达控制器之前，电源电流被转换或变换成交流电流，那么电源电流不一定是交流的。例如，本改进适用于各种形式的旋转变压器，如图 5 和 6 所示。

G' designates a continuous current motor, here represented as having four field poles wound with coils E" in shunt to the armature. The line wires A" A" connect with the brushes b b bearing on the usual commutator.

G'表示恒向电流电动机，这里表示为具有四个场磁极，线圈 E"与电枢并联。线路导线 A" A"与倚靠在普通换向器上的电刷 b b 连接。

On an extension of the motor shaft is a circuit controller composed of a cylinder, the surface of which is divided into four conducting segments c, and four insulating segments d, the former being diametrically connected in pairs as shown in Fig. 6.

在电动机轴的延伸部分上是由一个圆柱组成的电路控制器，其表面被分成四个导电分段 c 和四个绝缘分段 d，如图 6 所示，导电部分成对地径向连接。

Through the shaft run two insulated conductors $c\ c$ from any two commutator segments ninety degrees apart, and these connect with the two pairs of segments c , respectively. With such arrangement, it is evident that any two adjacent segments $c\ c$ become the terminals of an alternating current source, so that if two brushes $F\ F'$ be applied to the periphery of the cylinder they will take off current during such portion of the wave as the width of segment and position of the brushes may determine. By adjusting the position of the brushes relatively to the cylinder, therefore, the alternating current delivered to the segments $c\ c$ may be interrupted at any point of its waves.

穿过电动机轴引出两条被绝缘的导体 $c\ c$ ，分别连接到相隔 90 度的两对换向器分段 $c\ c$ 上。采用这种布置，很明显，任何两个相邻的分段 $c\ c$ 成为一个交流电源的终端，因此，如果两个电刷 $F\ F'$ 被施加到圆柱的外周，它们将在由分段的宽度和电刷的位置决定的波的这部分期间取走电流。因此，通过调整电刷相对于圆柱的位置，输送到分段 $c\ c$ 的交流电可以在其波的任何一点被中断。

While the brushes $F\ F'$ are on the conducting segments the current which they collect stores energy in a circuit of high self-induction formed by the wires $f\ f$, self-induction coils $S\ S$, the conductors $A''\ A''$, the brushes and commutator. When this circuit is interrupted by the brushes $F\ F'$, passing onto the insulating segments of the controller, the high potential discharge of this circuit stores energy in the condensers $H\ H$ which then discharge through the circuit of low self-induction containing the primary K . The secondary circuit contains any devices as P, R , for utilizing the current.

当电刷 $F\ F'$ 倚靠在导电分段上时，它们收集的电流将能量储存在由导线 $f\ f$ 、自感线圈 $S\ S$ 、导体 $A''\ A''$ 、电刷和换向器形成的高自感电路中。当该电路被电刷 $F\ F'$ 中断时，电刷 $F\ F'$ 正在经过控制器的绝缘分段，该电路的高电位放电将能量储存在电容器 $H\ H$ 中，然后电容器 $H\ H$ 通过包含了初级 K 的低自感电路进行放电。次级电路包含了任何利用电流的装置，如 $P、R$ 。

In some cases the energy delivered by the system may be readily and economically regulated. It is well known that every electric circuit, provided its ohmic resistance does not exceed certain definite limits, has a period of vibration of its own analogous to the period of vibration of a weighted spring. In order to alternately charge a given circuit of this character by periodic impulses impressed upon it and to discharge it most effectively, the frequency of the impressed impulses should bear a definite relation to the frequency of vibration possessed by the circuit itself. Moreover, for like reasons, the period of vibration of the discharge circuit should bear a similar relation to the impressed impulses or the period of the charging circuit. When the conditions are such that the general law of harmonic vibrations is followed, the circuits are said to be in resonance or in electro-magnetic synchronism, and this condition of the system is found to be highly advantageous.

在某些情况下，系统输送的能量可以容易地和经济地调节。众所周知，每一个电路，只要它的欧姆电阻不超过某个确定的极限，它都有自己的振动周期，类似于一个加重弹簧的振动周期。为了通过向这种特征的一个给定的电路施加周期性的脉冲来给该电路交替地充电并最有效地对其进行放电，所施加的脉冲的频率应该与电路本身所具有的振动频率具有一定的关系。此外，出于类似的原因，放电电路的振动周期应该与外加脉冲或充电电路的周期具有一个类似的关系。当条件符合谐波振动的一般规律时，电路被称为谐振或电磁同步，并且发现系统的这种条件是非常有利的。

In carrying out the invention, therefore, the electrical constants should be so adjusted that in normal operation the condition of resonance is approximately attained. To accomplish this, the number of impulses of current directed into the charging circuit per unit time is made equal to the period of the charging circuit itself, or, generally, to a harmonic thereof, and the same relations are maintained between the charging and discharge circuit. Any departure from this condition will result in a decreased output, and this fact is taken advantage of in regulating such output by varying the frequencies of the impulses or vibrations in the several circuits.

因此，在实施本发明时，应该调整电常数，使得在正常操作中，大致达到谐振条件。为了实现这一点，每单位时间导入充电电路的电流脉冲数等于充电电路本身的周期数，或者一般来说等于该电路的一个谐波数，并且在充电电路和放电电路之间保持相同的关系。任何偏离这一条件的情况都将导致输出减少，这一事实可被利用，通过改变几个电路中的脉冲或振动的频率来调节这种输出。

Inasmuch as the period of any given circuit depends upon the relations of its resistance, self-induction and capacity, a variation of any one or more of these may result in a variation in its period. There are, therefore, various ways in which the frequencies of vibration of the several circuits in the system may be varied, but the most practicable and efficient ways of accomplishing the desired result are the following:

因为任何给定电路的周期取决于其电阻、自感和电容的关系，任何一个或多个的变化都可能导致其周期的变化。因此，有各种方法可以改变系统中几个电路的振动频率，但实现预期结果的最实用和最有效的方法如下：

(a) Varying the rate of the impressed impulses or those which are directed from the source of supply into the charging circuit, as by varying the speed of the commutator or other circuit controller.

(a) 通过改变换向器或其他电路控制器的速度，来改变所施加的脉冲的速率或从电源导入充电电路的脉冲的速率。

(b) Varying the self-induction of the charging circuit.

(b) 改变充电电路的自感。

(c) Varying the self-induction or capacity of the discharge circuit.

(c) 改变放电电路的自感或容量。

To regulate the output of a single circuit which has no vibration of its own, by merely varying its period would evidently require, for any extended range of regulation, a very wide range of variation of period. But in the system described, a very wide range of regulation of the output may be obtained by a very slight change of the frequency of one of the circuits when the above mentioned rules are observed.

要调节一个自身没有振动的单独一个电路的输出，仅仅通过改变它的周期就能完成，但对于任何扩展的调节范围，显然需要一个非常宽的周期变化范围。但是在所描述的系统，当遵

守上述规则时,可以通过其中一个电路的频率进行非常轻微的改变来获得非常宽范围的输出调节。

Figs. 7, 8, 9 and 10 illustrate some of the more practicable means for effecting the regulation, as applied to a system deriving its energy from a source of direct currents.

图 7、8、9 和 10 展示了应用于实现调节的一些更实用的工具,如能用于从直流电源获得其能量的一个系统。

In each of the figures A" A" designate the conductors of a supply circuit of continuous current, G a motor connected therewith in any of the usual ways, and operating a current controller C which serves to alternately close the supply circuit through the motor or through a self-induction coil, and to connect such motor circuit with a condenser H, the circuit of which contains a primary coil K, in proximity to which is a secondary coil L serving as the source of supply to the working circuit or that in which are connected up the devices P R for utilizing the current.

在每个图中, A" A" 表示恒向电流的一个供电电路的导体, G 表示以任何通常方式与之连接的电动机,该电动机操作电流控制器 C,该电流控制器 C 用于通过电动机或通过自感线圈交替地闭合供电电路,并用于将这种电动机电路与一个电容器 H 连接,电容器 H 的电路包含一个初级线圈 K,在其附近是次级线圈 L,用作工作电路的电源,或者其中连接有利用电流的设备 P、R。

In order to secure the greatest efficiency in a system of this kind, it is essential, as before stated, that the circuits, which mainly as a matter of convenience are designated as the charging and the discharge circuits, should be approximately in resonance or electro-magnetic synchronism. Moreover, in order to obtain the greatest output from a given apparatus of this kind it is desirable to maintain as high a frequency as possible.

为了确保这种系统的最大效率,如前所述,主要为了方便起见被称为充电电路和放电电路的电路应该大致处于谐振或电磁同步。此外,为了从给定的一个这种装置中获得最大的输出,希望保持尽可能高的频率。

The electrical conditions, which are now well understood, having been adjusted to secure, as far as practical considerations will permit, these results, the regulation of the system is effected by adjusting its elements so as to depart in a greater or less degree from the above conditions with a corresponding variation of output. For example, as in Figure 7 the speed of the motor, and consequently of the controller, may be varied in any suitable manner, as by means of a rheostat R' in a shunt to such motor, or by shifting the position of the brushes on the main commutator of the motor or otherwise. A very slight variation in this respect by disturbing the relations between the rate of impressed impulses and the vibration of the circuit of high self-induction into which they are directed, causes a marked departure from the condition of resonance and a corresponding reduction in the amount of energy delivered by the impressed impulses to the apparatus.

现在已经很好理解的电气条件,已经被调整以确保这些结果,只要实际考虑允许,系统的调节通过调整其组件来实现,以便以相应的输出变化在更大或更小的程度上偏离上述条件。例

如，如图 7 所示，电动机的速度以及因此控制器的速度可以以任何合适的方式改变，例如通过与这种电动机并联的变阻器 R' ，或者通过改变倚靠在电动机主换向器上的电刷的位置或其他方式。通过扰乱外加脉冲的速率和它们被引向的高自感电路的振动之间的关系，在这方面的一个非常微小的变化会导致共振条件的显着偏离和由外加脉冲传递到设备的能量的量相应减少。

A similar result may be secured by modifying any of the constants of the local circuits as above indicated. For example, in Figure 8 the choking coil B is shown as provided with an adjustable core N' , by the movement of which into and out of the coil the self-induction, and consequently the period of the circuit containing such coil, may be varied.

如上所述，可以通过修改上述局部电路的任何常数来确保类似的结果。例如，在图 8 中，扼流线圈 B 被展示为配有一个可调磁芯 N' ，通过磁芯 N' 进出线圈的运动，可以改变线圈的自感，从而改变包含这种线圈的电路的周期。

As an example of the way in which the discharge circuit or that into which the condenser discharges, may be modified to produce the same result, there is shown in Figure 9 an adjustable self-induction coil R'' in the circuit with the condenser, by the adjustment of which coil the period of vibration of such circuit may be changed.

以放电电路的方式或电容器放电进入的电路为例，可以被修改以产生相同结果，在图 9 中展示了在具有电容器的电路中的可调自感线圈 R'' ，通过调节该线圈，可以改变该电路的振动周期。

The same result would be secured by varying the capacity of the condenser, but if the condenser were of relatively large capacity this might be an objectionable plan, and a more practicable method is to employ a variable condenser in the secondary or working circuit, as shown in Figure 10. As the potential in this circuit is raised to a high degree, a condenser of very small capacity may be employed, and if the two circuits, primary and secondary, are very intimately and closely connected, the variation of capacity in the secondary is similar in its effects to the variation of the capacity of the condenser in the primary. As a means well adapted for this purpose two metallic plates $S' S'$ adjustable to and from each other and constituting the two armatures of the condenser are shown.

通过改变电容器的容量可以确保相同的结果，但如果电容器的容量相对较大，这可能是一个不可取的方案，更可行的方法是在次级或工作电路中采用一个可变电容器，如图 10 所示。当该电路中的电势升高到一个很高的程度时，可以使用非常小容量的电容器，并且如果初级和次级这两个电路非常紧密地连接，则次级中的容量变化在效果上类似于初级中的电容器的容量变化。作为非常适合于此目的的一个工具，展示出了两个金属板 $S' S'$ ，它们可调节得彼此靠近和远离，并构成电容器的两个电容极板。

The description of the means of regulation is confined herein to a source of supply of direct current, for to such it more particularly applies, but it will be understood that if the system be supplied by periodic impulses from any source which will effect the same results, the regulation of the system may be effected by the method herein described.

这里对调节装置的描述只限于直流电源，因为它特别适用于直流电源，但应该理解，如果系统由任何能产生相同结果的电源的周期性脉冲供电，系统的调节可以用这里描述的方法来实现。

The circuit controller or the device which ensures the proper charging and discharging of the condenser may be of any construction that will perform the functions required of it. In illustration of the principle of construction and mode of operation, reference has been made only to forms of mechanism that make and break metallic contacts, but there need be no actual metallic contact, if provision be made for the passage of a spark between separated conductors. Such a device is illustrated in Figs. 11 to 15.

确保电容器正常充电和放电的电路控制器或装置可以是任何能实现所需功能的结构。在说明结构原理和操作模式时，仅提到了接通和断开金属触点的机械形式，但如果在分离的导体之间提供一个火花通道，则不需要实际的金属触点。这种装置在图 11 至 15 中展示。

A designates, in Fig. 11, a generator having a commutator a' and brushes a" bearing thereon, and also collecting rings b" b", from which an alternating current is taken by brushes b' in the well understood manner.

在图 11 中，A 表示一个发电机，它具有一个换向器 a' 和倚靠在其上的电刷 a"，以及集电环 b" b"，电刷 b' 以众所周知的方式从集电环 b" 获得交流电。

The circuit controller is mounted, in part, on an extension of the shaft c' of the generator, and in part on the frame of the same, or on a stationary sleeve surrounding the shaft. Its construction, in detail, is as follows: -

电路控制器一部分安装在发电机轴 c' 的延伸部分上，一部分安装在发电机的框架上，或者安装在围绕该轴的固定套筒上。其详细结构如下：

e' is a metal plate with a central hub e" which is keyed or clamped to the shaft c'. The plate is formed with segmental extensions corresponding in number to the waves of current which the generator delivers. These segments are preferably cut away, leaving only rims or frames, to one of the radial sides of which are secured bent metal plates i which serve as vanes to maintain a circulation of air when the device is in operation.

e' 是带有一个中心轮毂 e" 的一块金属板，中心毂 e" 被榫接在或被夹紧在轴 c' 上。该板形成有在数量上对应于发电机输送的电流波的分段延伸部分。这些分段最好地被切掉，只留下边缘或框架，弯曲金属板 i 被固定到边缘或框架的多个径向侧中的一侧并被用作叶片，以在装置工作时保持空气循环。

The segmental disk and vanes are contained within a close insulated box or case f mounted on the bearing of the generator, or in any other proper way, but so as to be capable of angular adjustment around the shaft. To facilitate such adjustment, a screw rod f', provided with a knob or handle, is shown as passing through the wall of the box. The latter may be adjusted by this rod, and when in proper position may be held therein by screwing the rod down into a depression in the sleeve or bearing as shown in Fig. 11.

扇形盘和叶片被包含在安装在发电机轴承上的一个封闭的被绝缘的盒或箱 f 内，或者以任何其他适当的方式，但是能够围绕轴进行角度调节。为了便于这种调节，配有一个旋钮或手柄的螺杆 f'，被展示为穿过箱体的壁。后者可以通过该螺杆来调节，并且当处于适当位置时，可以通过将杆向下拧入套筒中的或轴承中的凹陷来保持固定，如图 11 所示。

Air passages g g are provided at opposite ends of the box through which air is maintained in circulation by the action of the vanes.

空气通道 g g 设置在箱体的相对端，通过叶片的作用，空气通过该通道保持循环。

Through the sides of the box f, and through insulating gaskets h, when the material of the box is not a sufficiently good insulator, extend metallic terminal plugs l, l, with their ends in the plane of the conducting segmental disk e' and adjustable radially towards and from the edges of the segments.

当箱体 f 的材料不是足够好的绝缘体时，延伸金属终端插头 l l 穿过箱体 f 的侧面和绝缘垫圈 h，插头末端在导电扇形盘 e' 的平面内，并且可在朝向和远离扇形盘 e' 边缘的方向上径向地调节。

Devices of this character are employed in the manner illustrated in Fig. 13.

这种特性的装置以图 13 所示的方式使用。

A, in this figure, represents any source of alternating current, the potential of which is raised by a transformer of which B is the primary and B' the secondary.

在这幅图中，A 代表任何交流电源，它的电势由一个变压器升高，B 是变压器初级，B' 是次级。

The ends of the secondary circuit s are connected to the terminal plugs l, l, of an apparatus similar to that of Figures 11 and 12, and having segments rotating in synchronism with the alternations of the current source, preferably, as above described, by being mounted on the shaft of the generator, when the conditions so permit.

次级电路 s 的两端连接到类似于图 11 和 12 的装置的终端插头 l l 上，并且具有与电流源的交替同步旋转的分段，如上所述，在条件允许的情况下，最好能采用安装在发电机轴的方法来保持与电流源同步。

The plugs l, l, are then adjusted radially so as to approach more or less the path of the outer edges of the segmental disk, and so that during the passage of each segment in front of a plug a spark will pass between them, which completes the secondary circuit, s.

然后径向调节插头 l l，以便或多或少地接近扇形盘的外边缘的路径，并且使得在插头前面的每个扇形段通过期间，火花将在它们之间通过，这完成了次级电路 s

The box, or the support for the plugs l, is adjusted angularly so as to bring the plugs and segments into

proximity at the desired instants with reference to any phase of the current wave in the secondary circuit, and fixed in position in any proper manner.

盒子或插头 l 的支撑件被调整角度，以便在期望的关于在次级电路中的电流波的任何相位的时刻使插头和分段彼此接近，并以任何适当的方式固定在合适的位置。

To the plugs l, l, are also connected the terminals of a condenser or condensers, so that at the instant of the rupture of the secondary circuit s by the cessation of the sparks the energy accumulated in such circuit will rush into, and charge the condenser.

一个或多个电容器的终端也连接到插头 l l，从而在次级电路 s 由于火花停止而断开而的瞬间，在该电路中积累的能量将冲进电容器并对其充电。

A path of low self-induction and resistance, including a primary K of a few turns, is provided to receive the discharge of the condenser, when the circuit s is again completed by the passage of sparks, the discharge being manifested as a succession of extremely rapid impulses.

一条低自感和低电阻的路径，包括几匝的初级 K，被提供来接收电容器的放电，当电路 s 通过火花的通道再次完成时，放电表现为一连串极为迅速的脉冲。

By means of this apparatus effects of a novel and useful character are obtainable, but to still further increase the efficiency of the discharge or working current, there may be in some instances provided a means for further breaking up the individual sparks themselves. A device for this purpose is shown in Figures 14 and 15.

通过这种装置，可以获得一种新颖和有用的效果，但是为了进一步提高放电或工作电流的效率，在某些情况下，可以提供进一步分解单个火花本身的装置。图 14 和 15 展示了用于此目的装置。

The box or case f in these figures is fixedly secured to the frame or bearing of the generator or motor which rotates the circuit controller in synchronism with the alternating source. Within said box is a disk e' fixed to the shaft c' with projections d' extending from its edge parallel with the axis of the shaft. A similar disk e' on a spindle d'' in face of the first is mounted in a bearing in the end of the box f with a capability of rotary adjustment.

这些图中的盒子或箱子 f 被固定地安装在发电机或电动机的框架或轴承上，该发电机或电动机使电路控制器与交流电源同步旋转。在所述盒子内是一个固定在轴 c' 上的圆盘 e'，其突出部分 d' 从圆盘 e' 的边缘沿着平行于轴的轴线方向延伸。心轴 d'' 上的一个类似圆盘 e' 面对第一个圆盘，利用一个旋转调节能力，该心轴被安装在盒子 f 端部的一个轴承中。

The ends of the projections d' are deeply serrated or several pins or narrow projections placed side by side, as shown in Fig. 14, so that as those of the opposite disks pass each other a rapid succession of sparks will pass from the projections of one disk to those of the other.

如图 4 所示，突起 d' 的端部是深锯齿状的，或者是并排放置的几个销或窄突起，从而当面对

面的圆盘的突起端部彼此经过时,快速的一连串的火花将从一个圆盘的突起传递到另一个圆盘的突起。

The invention is not limited to the precise devices or forms of the devices shown and described. For example, when the source of supply is a circuit of high self-induction no special choking coils or the like need be employed. So, too, the condenser as a distinctive apparatus may be dispensed with when the capacity of its circuit is sufficiently great to accomplish the desired result. The circuit controller may, as already explained, be very greatly modified and varied in construction and principle of operation without departure from the invention.

本发明不限于所展示和描述的精确设备或设备形式。例如,当电源是一个高自感电路时,不需要使用特殊的扼流线圈或类似物。同样,当电路的电容量足够大以达到预期的效果时,作为特殊装置的电容器也可以省去。如同已经解释的,电路控制器可以在结构和操作原理上进行非常大的修改和变化,而不背离本发明。

In the illustrations given of the circuit controller, the contacts and insulating spaces are arranged for charging and discharging a single condenser, but it is obvious that a single motor and circuit controller may be used to operate more than one condenser, by charging one while discharging the other or others.

在给出的电路控制器的图示中,触点和绝缘空间被布置用于对单个电容器进行充电和放电,但是很明显,单个电动机和电路控制器可以用于操作一个以上的电容器,可以在对一个电容器进行充电的同时对另一个或其他电容器进行放电。

Having now particularly described and ascertained the nature of the said invention and in what manner the same is to be performed, as communicated to me by my foreign correspondent, I declare that what I claim is:-

现在已经特别描述和确定了上述发明的性质和以何种方式执行上述发明,我的外国通信者传达给我,我宣布我主张的是:—

1.The apparatus herein described for converting electric currents of the kind generally obtainable from municipal systems of electric distribution, into currents of high frequency, comprising in combination a circuit of high self-induction, a circuit controller adapted to make and break such circuit, a condenser into which the said circuit discharges when interrupted, and a transformer through the primary of which the condenser discharges, as set forth.

1、这里描述的用于将通常可从市政配电系统获得的那种电流转换成高频电流的装置,包括一个高自感电路;适于接通和断开这种电路的一个电路控制器;当所述电路被中断时接受该电路放电的一个电容器;以及一个变压器,电容器通过其初级线圈放电,如前所述。

2.The combination with a circuit of high self-induction and means for making and breaking the same, of a condenser around the point of interruption in the said circuit, and a transformer the primary of which is in the condenser circuit, as described.

2、一个组合,它包括一个高自感电路和用于接通和断开该电路的工具;在所述电路中的中

断点附近的一个电容器；以及一个变压器，其初级在电容器的电路中，如所描述的。

3.The combination with a circuit having a high self-induction, of a circuit controller for making and breaking said circuit, a motor for driving the controller, a condenser in a circuit connected with the first around the point of interruption therein, and a transformer the primary of which is in circuit with the condenser, as set forth.

3、一个组合，它包括一个高自感电路和用于接通和断开该电路的一个电路控制器；用于驱动该控制器的一个电动机；处在一个电路中的一个电容器，它在中断点附近与第一个电路连接；一个变压器，它的初级与电容器在一个电路中，如前所述。

4.The combination with an electric circuit of a controller for making and breaking the same, a motor included in or connected with said circuit so as to increase its self-induction and driving the said controller, a condenser in a circuit around the controller, and a transformer through the primary of which the condenser discharges, as set forth.

4、一个组合，它包括一个控制器的一个电路，该控制器用于接通和断开该电路、在所述电路中或与所述电路连接以增加其自感并驱动所述控制器的电动机、在控制器周围的一个电路中的一个电容器、以及一个变压器，电容器通过其初级线圈放电，如前所述。

5.The combination with a circuit of direct current, of a controller for making and breaking the same, a motor having its field or armature coils or both included in said circuit and driving said controller, a condenser connected with the circuit around the point of interruption therein, and a transformer, the primary of which is in the discharge circuit of the condenser, as set forth.

5、一个组合，它包括一个直流电路；一个控制器用于接通和断开该电路；一个电动机，其励磁线圈或电枢线圈或两者都被包含在所述电路中，并驱动所述控制器；一个电容器，它在上述电路中的中断点周围与电路连接；一个变压器，它的初级在电容器的放电电路中，如上所述。

6.The method herein described of converting alternating currents of relatively low frequency into currents of high frequency, which consists in charging a condenser by such currents of low frequency during determinate intervals of each wave of said current, and discharging the condenser through a circuit of such character as to produce therein a rapid succession of impulses, as set forth.

6、这里描述的将相对低频的交流电转换成高频电流的方法，包括在所述电流的每个波的确定时间间隔期间，通过这种低频电流对一个电容器充电，并通过具有这种特性的一个电路对该电容器放电，从而在其中产生快速连续的脉冲，如上所述。

7.The combination with a source of alternating current, a condenser, a circuit controller adapted to direct the current during determinate intervals of each wave into the condenser for charging the same, and a circuit into which the condenser discharges, as set forth.

7、一个组合，它包括一个交流电源；一个电容器；一个电路控制器；该控制器适合于在每个波的确定时间间隔期间将电流引入电容器中以对其进行充电；以及一个电路，电容器对该

电路进行放电，如上所述。

8.The combination with a source of alternating current, a synchronous motor operated thereby, a circuit controller operated by the motor and adapted to interrupt the circuit through the motor at determinate points in each wave, a condenser connected with the motor circuit and adapted on the interruption of the same to receive the energy stored therein, and a circuit into which the condenser discharges, as set forth.

8、一个组合，它包括一个交流电源；一个由此运行的同步电动机；一个电路控制器，它由电动机运行并适于在每个波中的确定点处中断通过电动机的电路，并且适于在该电路中断时接收存储在其中的能量；以及一个电路，电容器对该电路进行放电，如上所述。

9.The combination with a source of alternating current, a charging circuit in which the energy of said current is stored, a circuit controller adapted to interrupt the charging circuit at determinate points in each wave, a condenser, for receiving on the interruption of the charging circuit, the energy accumulated therein, and a circuit into which the condenser discharges when connected therewith by the circuit controller, as set forth.

9、一个组合，它包括一个交流电源；存储所述电流能量的一个充电电路；一个电路控制器，适于在每个波中的确定点中断充电电路；一个电容器，用于在充电电路中断时接收其中累积的能量；以及一个电路，当电容器通过电路控制器与该电路连接时，电容器对该电路进行放电，如上所述。

10.The method of regulating the energy delivered by a system for the production of high frequency currents, and comprising a supply circuit, a condenser, a circuit through which the same discharges, and means for controlling the charging of the condenser by the supply circuit and the discharging of the same, the said method consisting in varying the relations of the frequencies of the impulses in the circuits comprising the system, as set forth.

10、产生高频电流的系统所输送的能量的调节方法，该系统包括一个供电电路；一个电容器；一个电路，电容器对它进行放电；以及用于利用供电电路来控制对电容器进行充电和放电的工具；所述方法包括改变构成该系统的电路中的脉冲的频率的关系，如上所述。

11.The method of regulating the energy delivered by a system for the production of high frequency currents comprising a supply circuit of direct currents, a condenser adapted to be charged by the supply circuit and to discharge through another circuit, the said method consisting in varying the frequency of the impulses of current from the supply circuit, as set forth.

11、产生高频电流的系统所输送的能量的调节方法，该系统包括一个直流电源电路；适于由电源电路充电并通过另一电路放电的一个电容器；所述方法包括改变来自电源电路的电流脉冲的频率，如上所述。

12.The method of producing and regulating electric currents of high frequency which consists in directing impulses from a supply circuit into a charging circuit of high self-induction, charging a condenser by the accumulated energy of such charging circuit, discharging the condenser through a

circuit of low self-induction, raising the potential of the condenser discharge and varying the relations of the frequencies of the electrical impulses in the said circuits, as set forth.

12、产生和调节高频电流的方法，包括将脉冲从电源电路导入高自感的充电电路；利用该充电电路的累积能量对电容器充电；通过低自感电路对电容器放电；提高该电容器放电的电势；以及改变所述电路中电脉冲的频率关系，如上所述。

13.The combination with a source of current, of a condenser adapted to be charged thereby, a circuit into which the condenser discharges in a series of rapid impulses, and a circuit controller for effecting the charging and discharge of said condenser, composed of conductors movable into and out of proximity with each other, whereby a spark may be maintained between them and the circuit closed thereby during determined intervals, as set forth.

13、一个组合，它包括一个电流源；适合于被该电流源充电的一个电容器；一个电路，电容器以一连串快速的脉冲向它放电；以及用于实现所述电容器的充电和放电的电路控制器，该电路控制器由可移动到彼此靠近和远离的导体组成，由此火花可以在它们之间维持，并且电路由此在确定的时间间隔期间内闭合，如上所述。

14.The combination with a source of alternating current, of a condenser adapted to be charged thereby, a circuit into which the condenser discharges in a series of rapid impulses, and a circuit controller for effecting the charging and discharge of said condenser composed of conductors movable into and out of proximity with each other in synchronism with the alternations of the source, as set forth.

14、一个组合，它包括一个交流电源；适合于被该电流源充电的一个电容器；一个电路，电容器以一连串快速的脉冲向它放电；以及用于实现所述电容器的充电和放电的电路控制器，该电路控制器由可以与电源的交替同步地彼此靠近和远离的导体组成，如上所述。

15.A circuit controller for systems of the kind described, comprising in combination a pair of angularly adjustable terminals and two or more rotating conductors mounted to pass in proximity to the said terminals, as set forth.

15、用于所述类型系统的一种电路控制器，包括一对角度可调的终端和两个或多个旋转导体，所述旋转导体被安装成经过所述终端的附近，如上所述。

16.A circuit controller for systems of the kind described, comprising in combination two sets of conductors, one capable of rotation and the other of angular adjustment whereby they may be brought into and out of proximity to each other at determinate points and one or both being subdivided so as to present a group of conducting points, as set forth.

16、用于所述类型系统的一种电路控制器，包括两组导体，一组能够旋转，另一组能够角度调节，由此它们可以在确定的点处彼此接近或远离；并且一组或两组导体被细分，从而呈现一组导电点，如上所述。

Dated this 22nd day of September 1896.

1896 年 9 月 22 日申请。

Haseltine, Lake & Co.,

45 Southampton Buildings, London, W.C., Agents for the Applicant.

哈兹尔廷（雷克）公司，

位于伦敦西中央区南安普敦大厦 45 号，代理申请。

[This Drawing is a reproduction of the Original on a reduced scale.]

Fig. 1

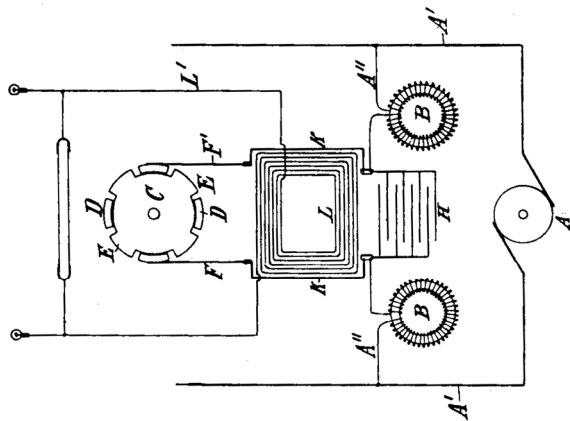


Fig. 2

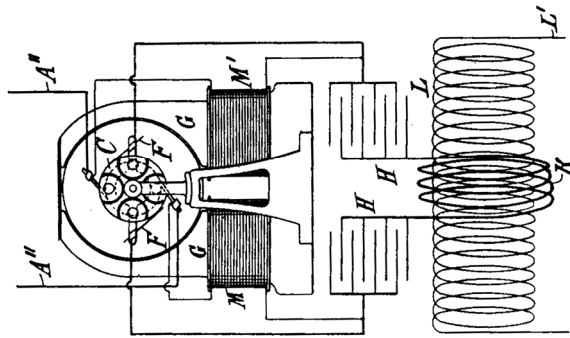


Fig. 3

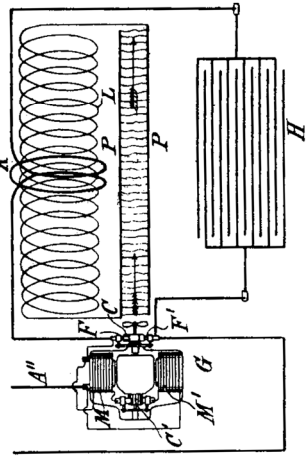


Fig. 9

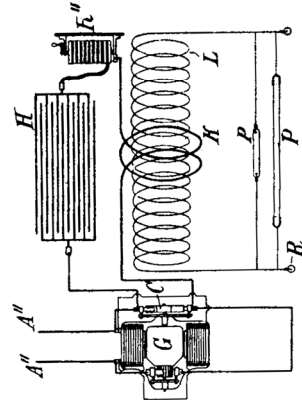


Fig. 8

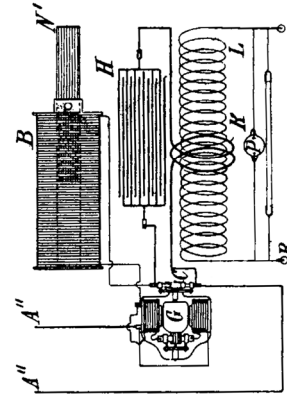


Fig. 7

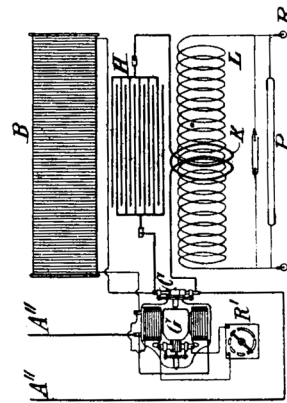
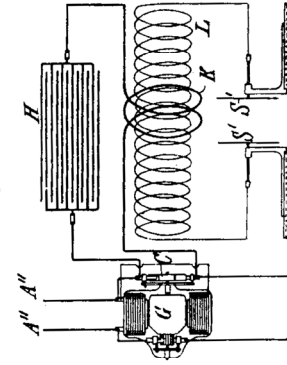


Fig. 10



[This Drawing is a reproduction of the Original on a reduced scale.]

Fig. 4

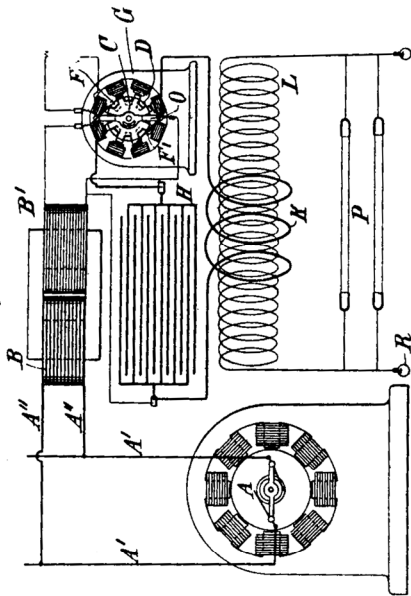


Fig. 5

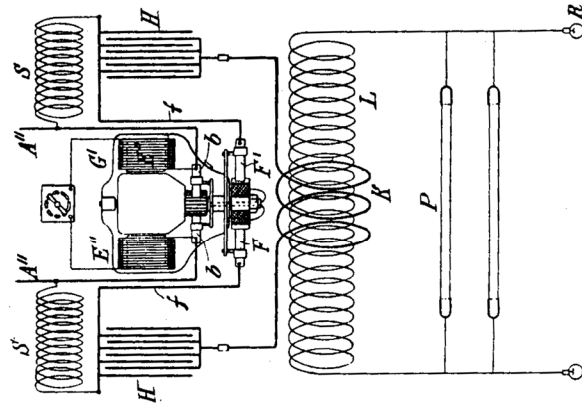


Fig. 6



Fig. 11

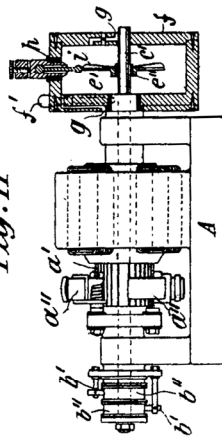


Fig. 12

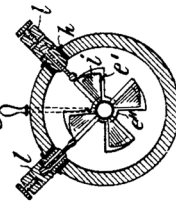


Fig. 13

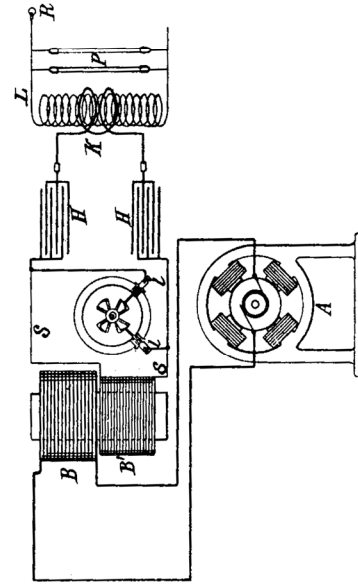


Fig. 15

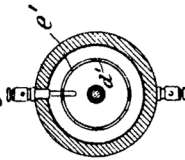
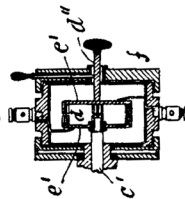


Fig. 14



ELECTRICAL-CIRCUIT CONTROLLER.

电路控制器

NIKOLA TESLA, OF NEW YORK, N. Y.

纽约州纽约市的尼古拉·特斯拉

SPECIFICATION forming part of Letters Patent No. 609,245, dated August 16, 1898.

Application filed December 2, 1897. Serial No. 660,518. (No model.)

该说明书形成了颁发于 1898 年 8 月 16 日编号为 609,245 的专利证书的一部分。

申请于 1897 年 12 月 2 日提交。序列号为 660,518。(没有模型)

To all whom it may concern:

致所有相关人士:

Be it known that I, NIKOLA TESLA, a citizen of the United States, residing at New York, in the county and State of New York, have invented certain new and useful Improvements in Electrical-Circuit Controllers, of which the following is a specification, reference being had to the drawings accompanying and forming a part of the same.

众所周知，我，尼古拉·特斯拉，一位美国公民，居住纽约州纽约郡纽约市，在电路控制器方面已经发明了某些新的和有用的改进，以下是该发明一个说明书，必须参考随附的图纸，它已形成该说明书的一部分。

In every form of electrical apparatus involving a means for making and breaking, more or less abruptly, a circuit a waste of energy occurs during the periods of make or break, or both, due to the passage of the current through an arc formed between the receding or approaching terminal or contacts, or, more generally, through a path of high resistance. The tendency of the current to persist after the actual disjunction or to precede the conjunction of the terminal exists in varying degrees in different forms of apparatus, according to the special conditions present. For example, in the case of an ordinary induction-coil the tendency to the formation of an arc at the break is, as a rule, the greater, while in certain forms of apparatus I have invented in which the discharge of a condenser is utilized this tendency is greatest at the instant immediately preceding the conjunction of the contacts of the circuit-controller which effects the discharge of the condenser.

在每种形式的电气设备中，包括或多或少突然地接通和断开一个电路的装置，由于电流通过时，在退缩或靠近的终端或触点之间产生的电弧的通路，或者更一般地，通过一条高电阻的路径，在接通或断开的期间，或在接通和断开的期间会发生一种能量浪费。根据存在的特殊条件，电流在实际断开之后或在终端连接之前持续存在的趋势在不同形式的设备中以不同的程度存在。例如，在普通感应线圈的例子中，通常在断路时形成电弧的趋势更大，而在我发明的利用电容器放电的某些形式的装置中，这种趋势在电路控制器的触点连接之前的瞬间最大，该电路控制器的触点实现了电容器的放电。

The loss of energy occasioned by the causes mentioned may be very considerable and is generally such as to greatly restrict the use of the circuit-controller and render impossible a practical and economical conversion of considerable amounts of electrical energy by its means, particularly in cases in which a high frequency of the makes and breaks is required.

由上述原因引起的能量损失可能是非常可观的，并且通常会极大地限制电路控制器的使用，并且使得不可能通过其措施来实现大量电能的实际的和经济的转换，特别是在需要高频率通断的情况下。

Extended experiment and investigation conducted with the aim of discovering a means for avoiding the loss incident due to the use of ordinary forms of circuit-controllers have led me to recognize certain laws governing the waste of energy and making it dependent chiefly on the velocity with which the terminal approach and recede from one another and also more or less on the form of the current-wave. Briefly stated, from both theoretical considerations and practical experiment it appears that the loss of energy in any device for making and breaking a circuit, other conditions being the same, is inversely proportional rather to the square than to the first power of the speed or relative velocity of the terminals in approaching and receding from one another in an instant in which the current-curve is not so steep as to materially depart from one which may be represented by a sine function of the time; but such a case seldom obtains in practice. On the contrary, the current-curve resulting from a make and break is generally very steep and particularly so when, as in my system, the circuit-controller effects the charging and discharging of a condenser, and consequently the loss of energy is still more rapidly reduced by increased velocity of approach and separation. The demonstration of these facts and the recognition of the impossibility of attaining the desired results by using ordinary forms of circuit-controllers led me to invent new and essentially different means for making and breaking a circuit in which I have utilized a conducting fluid, such as mercury, as the material for one or both of the terminals and devised novel means for effecting a rapidly-intermittent contact between the fluid and a conductor or series of conductors forming the other terminal.

扩展实验和调查的目的是发现一种方法，以避免由于使用普通形式的电路控制器的损失事件，这些扩展实验和调查使我认识到某些定律支配着能量的浪费，并使这种浪费主要取决于终端彼此接近和远离的速度，也或多或少取决于电流波的形式。简而言之，从理论考虑和实际实验来看，在其他条件相同的情况下，任何用于接通和断开电路的装置中的能量损失都与不同终端在一瞬间中彼此接近和远离的速度或相对速度的平方成反比，而不是与该速度或相对速度的一次幂成反比，在该一瞬间中，电流曲线并没有陡峭到以至于实质上偏离了电流的时间正弦函数曲线的程度；但在实践中很少出现这种情况。相反，由接通和断开产生的电流曲线通常非常陡峭，尤其是在我的系统中，当电路控制器实现电容器的充电和放电时，由此能量损失通过增加靠近和分离的速度而更快地减少。这些事实的证明，以及认识到使用普通形式的电路控制器不可能达到预期的结果，促使我发明了新的、本质上不同的方法来接通和断开电路，在这种方法中我利用了一种导电流体，如水银，作为一个或两个终端的材料，并设计了一种新颖的方法来实现该流体与形成另一个终端的导体（或一连串的导体）之间的快速间歇接触。

With a view, however, to securing a more practical and efficient circuit-controller in which not only the relative speed of the terminals but also the frequency of the makes and breaks should be very high I devised the form of instrument described in an application filed by me June 3, 1897, Serial No. 639,227,

in which a receptacle is rotated to impart a rapid movement to a body of conducting fluid contained herein, which is brought in rapidly-intermittent contact with a conductor having peripheral projections extending into the fluid, the movement of the latter being conveniently utilized to rotate the conductor. Such a device, though meeting fully many requirements in practice, is nevertheless subject to certain limitations in the matter of attaining a high relative speed of approach and separation of the terminals, since the path of movement of the conducting projections is not directly away from and toward the fluid, but more or less tangential to the surface of the latter, the velocity of approach and separation being of course the smaller the greater the diameter of the rotated conductor or terminal.

然而，为了获得一个更实用和高效的电路控制器，在该控制器中不仅不同终端的相对速度，而且接通和断开的频率都应该非常高，我设计了在我于 1897 年 6 月 3 日提交的序列号为 639,227 的申请中描述的一种仪器形式，在该仪器中，一个容器被旋转，以将快速运动传递给被容纳在其中的导电流体，该导电流体与一个导体快速间歇地接触，该导体具有延伸到该流体中的外围突起，导电流体的运动被方便地用于旋转导体。这种装置虽然在实践中完全满足许多要求，但是在获得终端的相对高的靠近和分离速度方面仍然受到一定的限制，因为导电突起的运动路径不是直接远离和朝向流体，而是或多或少与流体的表面相切，当然，被转动的导体或终端的直径越大，靠近和分离的速度越小。

With the object of securing a greater relative speed of the terminals and a consequently more efficient form of circuit-controller of this type I devised the modified form of apparatus which constitutes the subject of my present application.

为了确保终端的相对速度更快，从而得到一种更有效的这种类型的电路控制器，我设计了一种改进的装置，它构成了我的本申请的主题。

In this apparatus one of the members or terminals is a conducting fluid which is caused to issue from an orifice against a series of spaced conductors in rapid succession. For this purpose the series of conductors, or it may be a single conductor, is moved transversely through the stream or jet of fluid, or the jet is moved so as to impinge upon the conductors, or both jet and conductors are moved. This is preferably accomplished by mounting the conductors and the tube or duct from which the fluid issues concentrically and revolving one or both.

在该装置中，其中一个部件或终端是导电流体，该流体从一个喷孔快速连续地喷向一连串被间隔开的导体。为此目的，该一连串的导体，或者它可以是单个导体，被横向移动通过流体流束或射流，或者射流被移动以撞击导体，或者射流和导体都被移动。最好通过同心地安装导体以及流体所要流出的管或导管，并旋转其中之一或两者来实现。

The chief feature of novelty which distinguishes the apparatus and in which my improvement resides is the plan adopted for maintaining the stream or jet of conducting fluid. This consists in utilizing the same power that actuates or drives the circuit-controller in effecting the necessary relative movement of its terminals to maintain the proper circulation of the conducting fluid by combining the two mechanisms (the controller and the means for maintaining a circulation of the conducting fluid) in one. This feature is of great practical advantage and may be effected in many ways. A typical arrangement for this purpose is to provide a tube or duct having an orifice at one end directed toward the spaced conductors and its other end in a position to take up a portion of the rapidly-rotating body of

conducting fluid, divert it through the duct, and discharge it against the conductors. With this object when a closed receptacle is used a holder for the tube is employed, mounted within the receptacle and concentrically therewith, and this holder, when the receptacle is revolved, is held or influenced by any suitable means, as by magnetic attraction exerted from the outside or otherwise, in such manner as to keep it either in a fixed position or impress upon it a velocity different from that of the rotated fluid.

使该装置与众不同的新颖性的主要特征和我的改进之处在于维持导电流体的流束或射流的方案。这包括通过将两个机械装置（控制器和用于维持导电流体循环的装置）结合成一个机械装置，利用激励或驱动电路控制器的相同功率来实现其终端的必要相对运动，以维持导电流体的适当循环。该特征具有很大的实用优势，并且可以以多种方式实现。为此目的的一种典型布置是提供一种管或导管，其一端具有朝向被间隔开的导体的孔口，而其另一端处于一个位置，以带走一部分快速旋转的导电流体，使其转向通过导管，并对着导体排放。为此目的，当使用一个封闭的容器时，使用一个用于导管的夹持器，该夹持器被安装在容器内并与该容器同心，并且当容器旋转时，该夹持器由任何合适的装置抓住或支配，例如通过从外部施加的磁引力或其他方式，或者将该夹持器保持在一个固定位置，或者对该夹持器施加一个不同于被转动的流体的速度。

Such other improvements in details as I have devised and applied to the construction and operation of my improved circuit-controller will be more fully hereinafter described; but from the above general statement of the nature of the device it will be observed that by means of the same the velocity of relative movement of the two parts or elements may be enormously increased and the duration of the arc or discharge between them at the periods of make and break thereby greatly reduced without material increase in the power required to effect it and without impairing the quality of contact or deteriorating the terminals.

我已经设计并应用于我的改进后的电路控制器的构造和操作的其它细节改进将在下文中更充分地描述；但是从上述对该装置的性质的一般描述中，可以观察到，通过该装置，两个部件或组件的相对运动速度可以极大地增加，因此在接通和断开期间，它们之间的电弧或放电的持续时间大大减少，而不会显著增加实现该过程所需的功率，并且不会损害触点质量或损坏终端。

In the drawings hereto annexed, Figure 1 is a diagram illustrating the system for which the improvement was more especially designed. Fig. 2 is a top plan view of the circuit-controller. Fig. 3 is a view showing the induction-coil of Fig. 1 with its condenser-case in side elevation and the circuit-controller in vertical central section.

在附图中，图 1 是说明该系统的示意图，对该系统的改进是特别设计的。图 2 是电路控制器的俯视图。图 3 是展示出图 1 中的感应线圈的视图，其电容器外壳在侧视图中，电路控制器在垂直中心截面图中。

The general scheme of the system for use with which my improved circuit-controller is more especially designed will be understood by a brief reference to Fig 1. In said figure, A A represent the terminals of a source of current. A' is a self-induction or choking coil included in one branch of the circuit and permanently connected to one side of a condenser A". The opposite terminal of this condenser is connected to the other terminal of the source through the primary B of a transformer, the secondary

B' of which supplies the working circuit containing any suitable translating devices, as B''.

通过对图 1 的一个简要参考，与我的改进后的被特别设计的电路控制器一起使用的总体方案将被理解。在所述图中，A A 代表一个电流源的终端。A'是一个自感应线圈或扼流线圈，被包含在电路的一个分支中，并永久连接到电容器 A''的一侧。该电容器的另一端通过变压器的初级 B 连接到电源的另一端，变压器的次级 B'为包含任何适合的转换装置（如 B''）的工作电路供电。

The circuit-controller C, which is represented conventionally, operates to make and break a bridge from one terminal of the source to a point between the choking-coil A' and the condenser A'', from which it will result that when the circuit is completed through the controller the choking-coil A' is short-circuited and stores energy which is discharged into the condenser when the controller-circuit is broken, to be in turn discharged from the condenser through the primary B when these two are short-circuited by the subsequent completion of the controller-circuit.

运行常规表示的电路控制器 C 来接通和断开从电源的一个终端到扼流线圈 A'和电容器 A''之间的一个点的桥，由此将导致当电路通过控制器完成时，扼流线圈 A'被短路并且存储能量，当控制器电路断开时，该能量被释放到电容器中，当这两个组件通过控制器电路的随后的完成而被短路时，该能量又通过初级线圈 B 从电容器中释放。

I refer now to Figs. 2 and 3 for an illustration of the more important and typical features of my improved circuit-controller. The parts marked a compose a closed receptacle of cylindrical form having a dome or extension of smaller diameter. The receptacle is secured to the end of a spindle c, which is mounted vertically in bearings of any character suitable for the purpose. As it is intended to impart a rapid rotation to the receptacle a, I have shown a convenient device for this purpose comprising a field-magnet d, secured to the base or frame e, and an annular armature f, secured to the receptacle a. The coils of the armature are connected with the plates g of a commutator secured to the receptacle a and made in cylindrical form, so as to surround the socket in which the spindle c is stepped. A body of magnetic material h, which serves as an armature, is mounted on antifriction-bearings on an extension of the spindle c, so that the receptacle and the body h may have freely independent movements of rotation. Surrounding the dome b, in which the armature h is contained, is a core with pole-pieces o, which are magnetized by coils p, wound on the core. The said core is stationary, being supported by arms r, Fig. 2, independently of the receptacle, so that when the receptacle is rotated and the core energized the attractive force exerted by the poles o upon the armature h within the receptacle a holds the said armature against rotation. To prevent loss from currents set up in the shell of the dome b, the latter should be made of German silver or other similar precaution taken. An arm i is secured to the armature h within the receptacle a and carries at its end a short tube k, bent, as shown in Fig. 2, so that one open end is tangential to the receptacle-wall and the other directed toward the center of the same. Secured to the top plate of the receptacle a are a series of conducting-plates l. The part of the top plate s from which said conducting-plates l depend is insulated from the receptacle proper by insulating packing-rings t, but is electrically connected with the dome b, and in order to maintain electrical connection from an external circuit to the conductors l a mercury-cup w is set in the top of the dome, into which cup extends a stationary terminal plug n. A small quantity of a conducting fluid, such as mercury, is put into the receptacle a, and when the latter is rotated the mercury by centrifugal action is forced out toward its periphery and rises up along its inner wall. When it reaches the level of the open-mouthed

tube k, a portion is taken up by the latter, which is stationary, and forced by its momentum through the tube and discharged against the conductors l as the latter pass in rapid succession by the orifice of said tube. In this way the circuit between the receptacle and the conductors l is completed during the periods in which the stream or jet of mercury impinges upon any of the conductors l and broken whenever the stream is discharged through the spaces between the conductors.

我现在参考图 2 和 3 来说明我的改进后的电路控制器的更重要的和更典型的特征。标有 a 的部分组成一个圆柱形的封闭容器，该容器具有一个圆顶或直径较小的延伸部分。该容器被固定在心轴 c 的端部，该心轴被垂直安装在适合于该目的的任何特性的轴承中。由于它旨在使容器 a 快速旋转，因此我已经展示出用于此目的的一个便利装置，该装置包括被固定到底座或框架 e 上的一个场磁体 d 和被固定到容器 a 上的一个环形电枢 f。电枢的线圈与被固定在容器 a 上并被制成圆柱形的一个换向器的多个板 g 相连接，以便包围心轴 c 要插入的插孔。用作一个电枢的磁性材料体 h 被安装在心轴 c 的延伸部分上的滚动轴承上，使得容器和材料体 h 可以自由独立地旋转运动。圆顶 b 中容纳着电枢 h，包围着圆顶 b 的是具有极靴 o 的一个铁芯，该铁芯被缠绕其上的线圈 p 磁化。所述铁芯是固定的，由臂 r 支撑，如图 2 所示，独立于容器，从而当容器旋转且铁芯被励磁时，由磁极 o 施加在容器 a 内的电枢 h 上的吸引力抓住所述电枢，使其不能旋转。为了防止在圆顶 b 的外壳中建立的电流的损失，该外壳应由锌白铜制成或采取其他类似的预防措施。如图 2 所示，臂 i 被固定在容器 a 内的电枢 h 上，并在其端部携带一个弯曲的短管 k，所以一个开口端与容器壁相切，另一开口端指向容器壁的中心。一连串导电板 l 被固定在容器 a 的顶板上。所述导电板 l 所依附的顶板 s 的部分通过绝缘密封环 t 与容器完全绝缘，但是与圆顶 b 电连接，并且为了维持从外部电路到导体 l 的电连接，水银杯 w 被设置在圆顶的顶部，固定的终端插头 n 延伸到该杯中。少量的导电流体，例如水银，被放入容器 a 中，当容器 a 旋转时，水银通过离心作用被抵向容器外周，并沿着其内壁上升。当它到达开口管 k 的高度时，一部分被静止的管带走，并在其自身动量的作用下通过管，并在导体 l 快速连续地通过所述管的孔口时对着导体 l 排出。这样，在水银流束或射流冲击任何导体 l 的期间，容器和导体 l 之间的电路是完整的，而每当水银流束通过导体之间的空间排出时，电路被断开。

From the nature of the construction and mode of operation of the above-described apparatus it is evident that the relative speed of separation and approach of the two elements or terminals (the jet and the conductors l) may be extremely high, while such increased speed affects in no material respect the quality of contact.

从上述设备的结构和操作模式的性质来看，很明显，两个组件或终端（射流和导体 l）的分离和靠近的相对速度可能非常高，而这种增加了的速度对接触效果没有任何实质性影响。

A circuit-controller of the kind described is applicable and useful in many other systems and apparatus than that particularly described herein, and may be greatly modified in construction without departure from the invention.

所描述的这种类型的电路控制器在许多其他系统和设备中是适用的和有用的，而不仅仅是这里具体描述的那些，并且可以在不背离本发明的情况下在结构上进行很大的修改。

I am aware that a jet or stream of conducting fluid has heretofore been employed as a means for completing an electric circuit, and I do not claim, broadly, the employment of a conducting fluid in

such form as a contact or terminal; but so far as I am aware both purpose for which I employ such form of contact or terminal and the manner in which I apply it are wholly of my invention, neither having been heretofore proposed.

我知道,迄今为止,导电流体的射流或流束已被用作完成电路的一种措施,我并不主张这个,广义地说,导电流体的使用形式如触点或终端;但就我所知,我使用这种触点或终端形式的目的以及我使用它的方式完全是我的发明,迄今为止还没有人提出过。

What I claim is—

我主张的是—

1. The combination with a receptacle of a conductor or series of spaced conductors, a nozzle or tube for directing a jet or stream of fluid against the same, the nozzle and conductor being capable of movement relatively to each other, and means for maintaining a circulation of conducting fluid, contained in the receptacle, through the said nozzle, and dependent for operation upon such relative movement, as set forth.

1、包括容纳一个导体或一连串被间隔开的导体的容器、用于将流体射流或流束导向该容器的喷嘴或管的组合,该喷嘴和导体能够相对于彼此运动,以及用于维持被容纳在容器中的导电流体通过所述喷嘴的循环装置,该装置依赖于这种相对运动进行操作,如前所述。

2. The combination with a closed receptacle of a conductor or series of spaced conductors, a nozzle or tube for directing a jet or stream of fluid against the same, and means for forcing a conducting fluid contained in the receptacle through the said nozzle, these parts being associated within the receptacle and adapted to be operated by the application of a single actuating power, as set forth.

2、包括容纳一个导体或一连串被间隔开的导体的密封容器、用于将流体射流或流束导向该容器的喷嘴或管、以及用于迫使被容纳在容器中的导电流体通过所述喷嘴的装置的组合,这些部件在容器内与容器结合,并且适于通过施加单一驱动力来操作,如前所述。

3. The combination with a receptacle containing a series of spaced conductors, a duct within the receptacle having one of its ends directed toward the said conductors, means for maintaining a rapid movement of relative rotation between the said end and the conductors and means for maintaining a circulation of a conducting fluid contained in the receptacle through the duct against the conductors, the said conductors and jet constituting respectively the terminals or elements of an electric-circuit controller.

3、存在着一个组合,包括:容纳一系列被间隔开的导体的容器;容器内的一个导管,其一端指向所述导体;用于维持所述端和导体之间相对快速旋转的装置;以及用于维持容器内被容纳的导电流体通过导管射向导体的循环的一个装置;所述导体和射流分别构成电路控制器的终端或组件。

4. The combination with a receptacle capable of rotation and containing a series of spaced conductors, a duct within the receptacle having an orifice directed toward the said conductors, and an open end in

position to take up a conducting fluid from a body of the same contained in the receptacle, when the latter is rotated, and direct it against the conductors, the said conductors and the fluid constituting the terminal or elements of an electric-circuit controller.

4、存在着一个组合，包括：能够旋转并包含一连串被间隔开的导体的一个容器；容器内的一个导管，该导管具有指向所述导体的孔口；以及一个开口端，当容器旋转时，该开口端在适当位置从被包含在容器内的容器主体中带走导电流体，并将其导向导体，所述导体和流体构成电路控制器的终端或组件。

5. The combination with a receptacle for containing a conducting fluid and a series of spaced conductors thereon, of a duct having an orifice directed toward the said conductors and forming a conduit through which the fluid when the receptacle is rotated is forced and thrown upon the conductors.

5、包括用于容纳导电流体的容器和该容器上的一连串被间隔开的导体，以及一个导管的组合，该导管具有朝向所述导体的孔口，并形成一条输送管，当容器旋转时，流体通过该输送管被推动并被喷射到导体上。

6. The combination with a receptacle capable of rotation, and a series of conductors mounted therein, of a duct having an orifice directed toward the conductors, a holder for said duct mounted on bearings within the receptacle which permit of a free relative rotation of said receptacle and holder, and means for opposing the rotation of the said holder in the direction of the movement of the fluid while the receptacle is rotated, whereby the conducting fluid within the receptacle will be caused to flow through the duct against the conductors.

6、存在着一个组合，包括：具有能够旋转的容器和安装在其中的一连串的导体；一个导管，它的一个开孔朝向导体；被安装在容器内的轴承上的用于所述导管的一个夹持器，该夹持器允许所述的容器和夹持器的一种自由的相对旋转；以及用于在容器旋转时阻碍所述夹持器在流体运动方向上旋转的装置，由此容器内的导电流体将流过导管冲向导体。

7. The combination with a receptacle and a motor for rotating the same, of a magnetic body mounted in the receptacle, a magnet exterior to the receptacle for maintaining the body stationary while the receptacle rotates, a series of conductors in the receptacle and a duct carried by the said magnetic body and adapted to take up at one end a conducting fluid in the receptacle when the latter rotates and to direct such fluid from its opposite end against the series of conductors.

7、存在着一个组合，包括：一个容器和用来转动该容器的一个电动机；被安装在该容器中的一个磁体；位于容器外部的一个磁体，用于在容器旋转时维持容器内的磁体静止；容器中的一连串的导体和由所述磁体携带的一个导管，在该容器中，该导管适合于带走位于一端的导电流体，当该容器旋转时，这种流体从导管的另一端冲向所述的一连串导体。

8. The combination with a receptacle for containing a conducting fluid, a series of spaced conductors within the same, and a motor, the armature of which is connected with the receptacle so as to impart rotation thereto, a magnetic body capable of turning freely within the receptacle about an axis concentric with that of the latter, a duct carried by the said body having one end in position to take up the conducting fluid and the other in position to discharge it against the spaced conductors, and a magnet

exterior to the receptacle for holding the magnetic body stationary when the receptacle is rotated.

8、存在着一个组合，包括：用于容纳导电流体的一个容器；容器内的一连串被间隔的导体；一个电动机，电动机的电枢与容器连接以使该容器旋转；能够在容器内围绕与容器同心的轴线自由旋转的一个磁体；由所述磁体携带的一个导管，其一端在适当位置带走导电流体，另一端在适当位置将导电流体喷射到被间隔开的导体上；以及在容器外部的磁体，用于在容器旋转时保持容器内的磁体静止。

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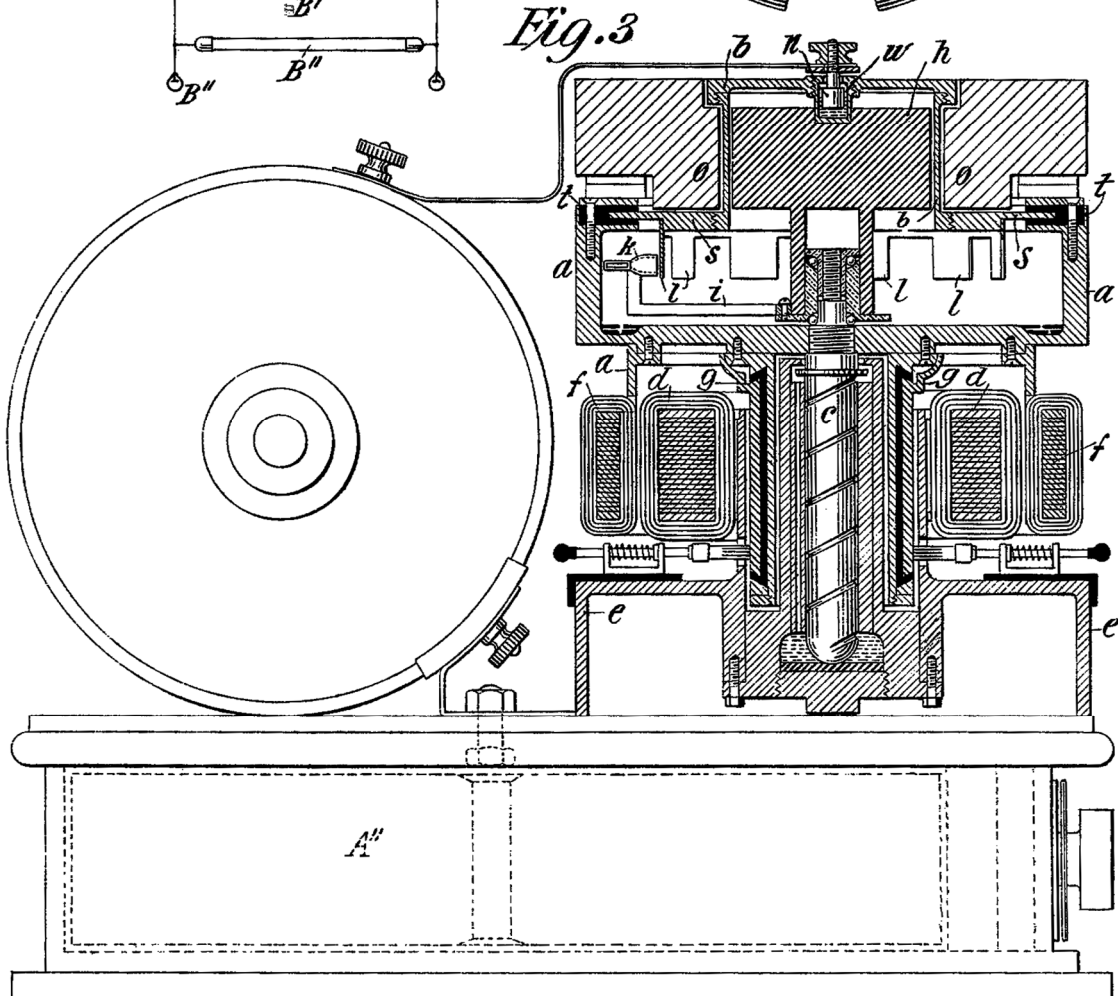
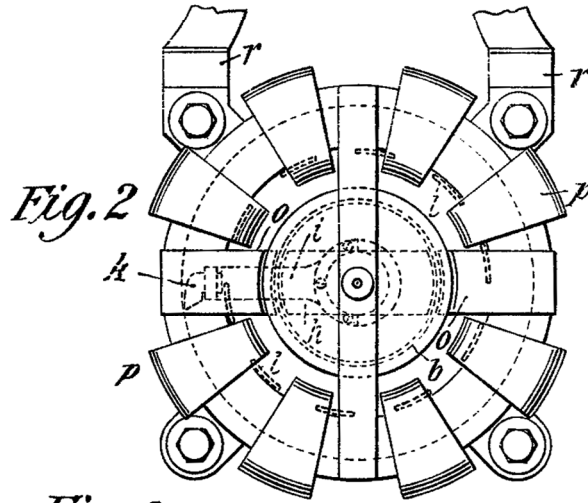
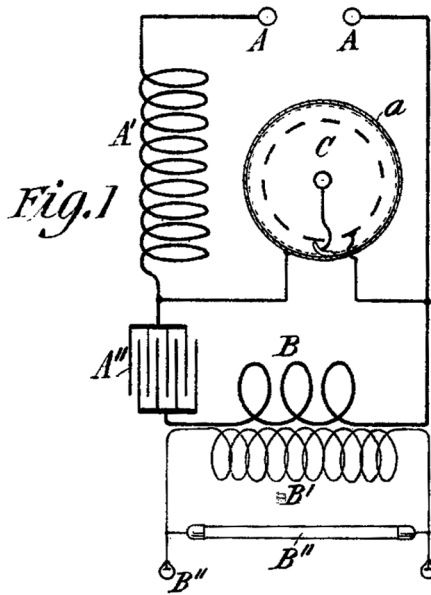
No. 609,245.

Patented Aug. 16, 1898.

N. TESLA.
ELECTRICAL CIRCUIT CONTROLLER.

(Application filed Dec. 2, 1897.)

(No Model.)



Witnesses:
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ELECTRIC-CIRCUIT CONTROLLER.

电路控制器

NIKOLA TESLA, OF NEW YORK, N. Y.

纽约州纽约市的尼古拉·特斯拉

SPECIFICATION forming part of Letters Patent No. 609,246, dated August 16, 1898.

Application filed February 28, 1898. Serial No. 671,897. (No model.)

该说明书形成了颁发于 1898 年 8 月 16 日编号为 609,246 的专利证书的一部分。

申请于 1898 年 2 月 28 日提交。序列号为 671,897。(没有模型)

To all whom it may concern:

致所有相关人士:

Be it known that I, NIKOLA TESLA, a citizen of the United States, residing in the borough of Manhattan, in the city, county, and State of New York, have invented certain new and useful Improvements in Electric-Circuit Controllers, of which the following is a specification, reference being had to the drawing accompanying and forming a part of the same.

众所周知，我，尼古拉·特斯拉，一位美国公民，居住纽约州纽约郡纽约市的曼哈顿区，在电路控制器方面已经发明了某些新的和有用的改进，以下是该发明一个说明书，必须参考随附的图纸，它已形成该说明书的一部分。

The invention which forms the subject of my present application is an improvement in a novel class of circuit-controlling appliances heretofore invented by me and more especially designed to be used with my now well-known apparatus for the production of electric currents of high frequency by means of condenser-discharges, but applicable generally as a means for making and breaking an electric circuit.

构成本申请主题的发明是对迄今为止由我发明的一类新型电路控制设备的改进，该类设备是专门被设计成与我的现在广为人知的利用电容器放电来产生高频电流的装置一起使用，但通常可用作接通和断开电路的装置。

In the circuit-controllers of the particular class or type to which my present improvement pertains I have utilized a conducting liquid as one of the terminals and have employed as the other terminal a solid conductor and provided various means for bringing the two into rapidly-intermittent contact.

在我目前的改进所涉及的特定种类或类型的电路控制器中，我使用一种导电液体作为一个终端，使用固体导体作为另一个终端，并提供各种装置使两者快速间歇接触。

The distinguishing feature of my present improvement lies chiefly in the use of a conducting liquid for both the terminals under conditions which permit of a rapidly-intermittent contact between them, as

will be herein set forth.

我的改进的显著特征主要在于，在允许两个终端快速间歇接触的条件下，将导电液体用于两个终端，这将在下面阐述。

The accompanying drawing illustrates an apparatus embodying the principle of my said improvement.

附图说明了能体现我所述的改进的原理的一种装置。

The figure is a central vertical section of the circuit-controller.

该图是电路控制器的中心垂直剖面图。

In the drawing is shown a receptacle composed of two cylindrical metallic portions A A', secured together by bolts B and nuts C, but insulated from each other. The receptacle is journaled, by means of trunnions formed on or secured to its ends, in standards D D, and any suitable means is employed to impart rotation to it. This is conveniently effected by constructing or organizing the receptacle in such manner that it may serve as the rotating element of an electromagnetic motor in conjunction with a surrounding stationary element E E. The abutting ends of the two parts of the receptacle are formed with inwardly-extending flanges F, which divide the peripheral portions of the receptacle into two compartments G G'. Into one of these compartments, as G, extends a spindle H, having its bearing in the end of the part A and the trunnion secured to or extending therefrom. Into the other compartment G' extends a spindle H', similarly journaled in the end of part A' and its trunnion. Each spindle carries or is formed with a weighted arm K, which, remaining in a vertical position, holds its spindle stationary when the receptacle is revolved.

在图中展示了由两个圆筒形金属部分 A A'组成的一个容器，这两个金属部分通过螺栓 B 和螺母 C 固定在一起，但是彼此绝缘。该容器被安装上轴颈并形成一端部，在立柱 D D 中形成于或固定于该容器端部的耳轴，并且采用任何合适的方式来使该容器旋转。可以通过以这样的方式构造或组织容器来方便地实现这一点，即它可以作为电磁电动机的旋转组件与周围的固定组件 E E 协同使用。容器的两个部分的邻接端形成有向内延伸的凸缘 F，凸缘 F 将容器的外围部分分成两个隔间 G G'。心轴 H 延伸到这些隔间中的一个，如 G，心轴 H 的轴承在部件 A 的端部，耳轴被固定到部件 A 或从部件 A 延伸出来。心轴 H' 延伸到另一个隔间 G' 中，类似地在部件 A' 的端部和它的耳轴中安装轴颈。每个心轴携带或形成具有一个配重臂 K，当容器旋转时，配重臂 K 被保持在竖直位置，保持它的心轴静止。

To the weighted arm of spindle H is secured a standard L, carrying a tube L', with one open end in close proximity to the inner peripheral wall of the compartment G and the other directed toward the axis, but inclined toward the opposite compartment. To the weighted arm of spindle H' is similarly secured a standard M, which is hollow and constitutes a portion of a duct or passage which extends through a part of the spindle and opens through a nozzle M' into a circular chamber N in the wall of the part A'. From this chamber run passages N' to nozzles O, in position to discharge jets or streams of liquid in such directions as to intersect, when the nozzles are rotated, a stream issuing from the end of tube L'.

心轴 H 的配重臂上固定着一根立柱 L，它带有一根管子 L'，管子 L'的一个开口端靠近隔室 G 的内周壁，另一个开口端朝向轴线，但向对面的隔室倾斜。心轴 H'的配重臂上同样固定有一个立柱 M，该立柱 M 是中空的，并构成一条导管或通道的一部分，该导管或通道延伸穿过心轴的一部分，并通过一个喷嘴 M'通向部件 A'的壁中的圆形腔室 N。通道 N'从该腔室延伸到喷嘴 O，这些喷嘴处于在交叉方向上释放液体射流或流束的位置上，当喷嘴旋转时，液体流束从管 L'的末端流出。

In each portion or compartment of the receptacle is placed a quantity of a conducting liquid, such as mercury, and the ends of the tubes L' and M are provided with openings which take up the mercury when on the rotation of the receptacle it is carried by centrifugal force against the peripheral wall. The mercury when taken up by the tube L' issues in a stream or jet from the inner end of said tube and is projected into the compartment G'. The mercury taken up by the tube M runs into the circular chamber N, from which it is forced through the passages N' to the nozzles O, from which it issues in jets or streams directed into the compartment G. As the nozzles O revolve with the receptacle the streams which issue from them will therefore be carried across the path of the stream which issues from the tube L' and which is stationary, and the circuit between the two compartments will be completed by the streams whenever they intersect and interrupted at all other times.

在容器的每个部分或隔室中放置一定量的导电液体，如水银，并且管 L'和 M 的端部设置有开口，当容器旋转时，水银在离心力的作用下被抵靠在外周壁上，从而使得这些开口带走水银。当水银被管 L'带走时，从所述管的内端以流束或射流的形式射出，并射入隔间 G'中。由管 M 带走的水银流入圆形腔室 N 中，从那里水银被迫通过通道 N'并到达喷嘴 O，从那里，水银以射流或流束的形式直接进入隔间 G。当喷嘴 O 与容器一起旋转时，从它们流出的流束将因此穿过从管 L'流出的静止的流束路径，并且每当这些流束相交时，两个隔室之间的电路将由这些流束完成，并且在所有其它时间内，这个电路被中断。

The continuity of the jets or streams is not preserved ordinarily to any great distance beyond the orifices from which they issue, and hence they do not serve as conductors to electrically connect the two sides of the receptacle beyond their point of intersection with each other.

射流或流束的连续性通常不会保持到它们发出的孔口之外的任何很大的距离，因此它们不会被作为导体来电连接超出它们彼此交点的容器两侧。

It will be understood that so far as the broad feature of maintaining the terminal jets is concerned widely-different means may be employed for the purpose and that the spindles mounted in free bearings concentrically with the axis of rotation of the receptacle and held against rotation by the weighted arms constitute but one specific way of accomplishing this result. This particular plan, however, has certain advantages and may be applied to circuit-controllers of this class generally whenever it is necessary to maintain a stationary or nearly stationary body within a rotating receptacle. It is further evident from the nature of the case that it is not essential that the jet or jets in one compartment or portion of the instrument should be stationary and the others rotating, but only that there should be such relative movement between them as to cause the two sets to come into rapidly-intermittent contact in the operation of the device.

可以理解的是，就维持终端射流的广泛特征而言，可以采用不同的装置来实现这一目的，并

且安装在与容器的旋转轴线同心的自由轴承中的并由配重臂保持防止旋转的心轴,仅构成实现这一结果的一种特定方式。然而,这种特殊的方案具有某些优点,只要有必要在旋转容器内保持一个静止或接近静止的物体,就可以应用于这类电路控制器。从这种情况的性质进一步明显看出,那就是在仪器的一个隔室中或一个部分中的一个或多个射流应该是静止的而其他的射流是旋转的,以上这点不是必须的,而仅仅是它们之间应该有这样的相对运动,使得两组射流在装置的运行中能快速间歇地接触。

The number of jets, whether stationary or rotating, is purely arbitrary; but since the conducting fluid is directed from one compartment into the other the aggregate amount normally discharged from the compartments should be approximately equal. However, since there always exists a tendency to project a greater quantity of the fluid from that compartment which contains the greater into that which contains the lesser amount no difficulty will be found in this respect in maintaining the proper conditions for the satisfactory operation of the instrument.

无论是射流静止的还是旋转的,射流的数量都是完全任意的;但是由于导电流体从一个隔室被引导到另一个隔室,所以通常从不同隔室排出的总量应该大致相等。然而,由于总是存在一种趋势,即从容纳较多流体的那个隔室向容纳较少流体的那个隔室中喷射较大量的流体,因此在维持仪器令人满意的运行的适当条件方面不会发现困难。

A practical advantage, especially important when a great number of breaks per unit of time is desired, is secured by making the number of jets in one compartment even and in the other odd and placing each jet symmetrically with respect to the center of rotation. Preferably the difference between the number of jets should be one. By such means the distances between the jets of each set are made the greatest possible and hurtful short-circuits are avoided.

通过使一个隔室中的喷嘴数量为偶数而另一个隔室中的喷嘴数量为奇数,并且相对于旋转中心对称地放置每个喷嘴,这样确保了一个实际的优势,当希望每单位时间有大量的中断时,这样做尤其重要。喷嘴数量之间的差值最好应该是1。通过这种方式,使得每组喷嘴之间的距离尽可能最大,并且避免了有害的短路。

For the sake of illustration let the number of jets or nozzles L' in one compartment be nine and the number of those marked O in the other compartment ten. Then by one revolution of the receptacle there will be ninety makes and breaks. To attain the same result with only one jet, as L' , it would be necessary to employ ninety jets O in the other compartment, and this would be objectionable, not only because of the close proximity of the jets, but also of the great quantity of fluid required to maintain them.

为了说明起见,假设一个隔室中的喷口或喷嘴 L' 的数量为9,而另一个隔室中标记 O 的数量为10。那么容器每转一周,就会有九十次接通和断开。为了仅用一个喷口,如 L' ,来获得相同的结果,必须在另一个隔室中使用90个喷射器 O ,这将是不可取的,不仅因为喷射器靠得很近,而且还因为维持它们需要大量的流体。

In the use of the instrument as a circuit-controller it is merely necessary to connect the two insulated parts of the receptacle to the two parts of the circuit, respectively, as by causing brushes XY , connected with circuit-wires, to bear at any suitable points on the said two parts $A A'$.

在将该仪器用作电路控制器时,仅仅需要将容器的两个被绝缘部分分别连接到电路的两个部分,例如通过使与电路导线连接的电刷 X Y 倚靠在在所述两个部分 A A'上的任何合适的点上。

In instruments of this character in which both terminals are formed by a liquid element there is no wear or deterioration of the terminals and the contact between them is more perfect. The durability and efficiency of the devices are thus very greatly increased.

在这种特征的仪器中,两个终端都由液体组件形成,终端没有磨损或退化,并且它们之间的接触更加完美。因此,设备的耐用性和效率大大提高。

Having now described my invention, what I claim is—

我现在已经描述了我的发明,我主张的是—

1. A circuit-controller comprising in combination means for producing streams or jets of conducting liquid forming the terminals, and means for bringing the jets or streams of the respective terminals into intermittent contact with each other, as set forth.

1、一种电路控制器,包括:用于产生导电液体流束或射流的装置,这种液体用来形成终端;以及用于使各个终端的射流或流束彼此间歇地接触的装置,如前所述。

2. In a circuit-controller, the combination with two sets of orifices adapted to discharge jets in different directions, means for maintaining jets of conducting liquid through said orifices, and means for moving said orifices relatively to each other so that the jets from those of one set will intermittently intersect those from the other, as set forth.

2、在一个电路控制器中,存在一个组合,包括:两组适于沿不同方向喷射射流的孔口;用于维持导电液体射流通过所述孔口的装置;以及用于使所述孔口彼此相对移动的装置,使得来自一组孔口的射流将间歇地与来自另一组孔口的射流相交,如前所述。

3. The combination in a circuit-controller of ducts and means for discharging therefrom streams or jets of conducting fluid in electrical contact with the two parts of the circuit respectively, the orifices of said ducts being capable of movement relatively to each other, whereby the streams discharged therefrom will intersect at intervals during their relative movement, and make and break the electric circuit, as set forth.

3、在一个电路控制器中的导管和用于从该导管排出分别与电路的两个部分电接触的导电流体流束或射流的装置的组合,所述导管的孔口能够相对于彼此运动,由此从这些孔口排出的流束将在它们的相对运动期间间歇地相交,并且接通和断开电路,如前所述。

4. In a circuit-controller the combination with one or more stationary nozzles and means for causing a conducting fluid forming one terminal to issue therefrom, of one or more rotating tubes or nozzles, means for causing a conducting liquid forming the other terminal to issue therefrom, the said rotating nozzles being movable through such a path as to cause the liquid issuing therefrom to intersect that

from the stationary nozzles as set forth.

4、在一个电路控制器中存在一个组合，包括：一个或多个固定喷嘴和用于使形成一个终端的导电流体流出的装置；一个或多个旋转管或喷嘴和用于使形成另一个终端的导电流体流出的装置，所述旋转喷嘴可移动通过这样的路径，以使从这些旋转喷嘴流出的液体与从固定喷嘴流出的液体相交，如上所述。

5. The combination with a rotating receptacle divided into two insulated compartments, a spindle in one compartment with its axis concentric with that of the receptacle, means for opposing the rotation of said spindle, and a tube or duct carried by the spindle and adapted to take up a conducting fluid at one end from the inner periphery of the compartment when the receptacle is rotated and direct it from the other end into the other compartment, of a similar spindle in the other compartment and means for opposing its rotation, a tube carried by the spindle and having an opening at one end near the inner periphery of the compartment and discharging into a chamber from which lead one or more passages to nozzles fixed to the rotating receptacle and adapted to discharge across the path of the jet from the stationary nozzle, as set forth.

5、存在一个组合，包括：被分成两个绝缘隔室的一个旋转容器；一个隔室中的心轴，该心轴的轴线与容器的轴线同心；用于阻止所述心轴旋转的装置；以及由心轴携带的管或导管，该管或导管适于在容器旋转时在一端从隔室的内周带走导电流体，并将该流体从另一端导入另一个隔室；在另一个隔室中具有类似的心轴和用于阻止其旋转的装置；由该心轴携带的一个管，该管在靠近该隔室的内周的一端有一个开口，并且该管排放流体到一个腔室中，一个或多个通道从该腔室被引向被固定到旋转容器上的喷嘴，并且该管排放的射流适于穿过来自静态喷嘴的射流路径，如前所述。

6. In a circuit-controller the combination with a rotating receptacle of a body mounted therein and formed or provided with a weighted portion eccentric to this axis which opposes its rotation and a tube or duct carried by said body and adapted to take up a conducting fluid from the rotating receptacle, as set forth.

6、在一个电路控制器中，存在一个组合，包括：安装在该控制器中的一个旋转容器主体；并且形成或配有偏心于该轴的配重部分，该配重部分阻碍主体的旋转；以及由所述主体携带的管或导管，该管或导管适于从旋转容器中带走导电流体，如前所述。

7. In a circuit-controller the combination of two sets of nozzles and means for projecting from the same, jets of conducting fluid which constitute respectively the terminals of the controller, means for moving the nozzles relatively to each other so that the jets of the two sets are brought successively into contact, the nozzles of each set being arranged symmetrically about an axis of rotation, there being one more nozzle in one set than in the other.

7、在一个电路控制器中，存在一个组合，包括：两组喷嘴和用于从这两组喷嘴喷射导电流体射流的装置；这些射流分别构成控制器的不同终端；用于使喷嘴相对于彼此移动以使两组射流连续接触的装置，每组喷嘴相对于旋转轴对称布置，一组喷嘴比另一组多一个喷嘴。

NIKOLA TESLA.

尼古拉·特斯拉

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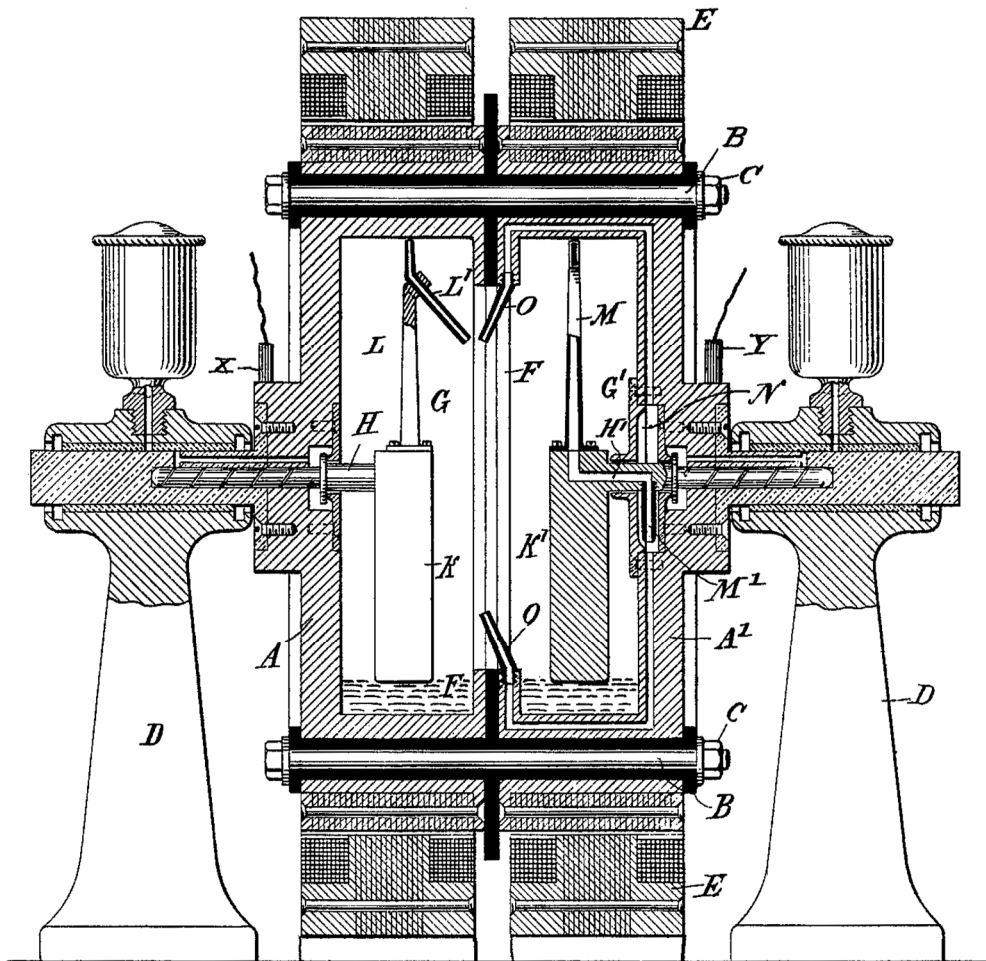
No 609,246.

Patented Aug. 16, 1898.

N. TESLA.
ELECTRIC CIRCUIT CONTROLLER.

Feb. 28, 1898.

(No Model.)



Witnesses:
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ELECTRIC-CIRCUIT CONTROLLER.

电路控制器

NIKOLA TESLA, OF NEW YORK, N. Y.

纽约州纽约市的尼古拉·特斯拉

SPECIFICATION forming part of Letters Patent No. 609,247, dated August 16, 1898.

Application filed March 12, 1898. Serial No. 673,558. (No model.)

该说明书形成了颁发于 1898 年 8 月 16 日编号为 609,247 的专利证书的一部分。

申请于 1898 年 3 月 12 日提交。序列号为 673,558。(没有模型)

To all whom it may concern:

致所有相关人士:

Be it known that I, NIKOLA TESLA, of the borough of Manhattan, in the city, county, and State of New York, have invented certain new and useful Improvements in Circuit-Controllers, of which the following is a specification, reference being had to the drawings accompanying and forming a part of the same.

众所周知，我，尼古拉·特斯拉，一名美国公民，居住在纽约州纽约郡纽约市的曼哈顿区，在电路控制器方面已经发明了某些新的和有用的改进，以下是该发明一个说明书，必须参考随附的图纸，它已形成了该说明书的一部分。

In an application filed by me on June 3, 1897, Serial No. 639,227, I have shown and described a device for making and breaking an electric circuit comprising a rotary receptacle containing a conducting fluid and a terminal mounted within but independently of the receptacle and caused by the rotation of the latter to make and break electrical contact with the fluid.

在本人于 1897 年 6 月 3 日提交的序列号为 639,227 的申请中，本人已经展示并描述了一种用于接通和断开电路的装置，该装置包括容纳导电流体的旋转容器和安装在容器内但独立于容器的终端，该终端通过容器的旋转来接通和断开与流体的电接触。

The invention on which my present application is based is an improvement in devices of this particular class, and has primarily as its object the production of a circuit-controller in which an independently-mounted terminal operated in a similar manner by a rotating body of conducting fluid may be enclosed within a gas-tight receptacle.

我的本申请所基于的发明是对这种特殊类型的装置的改进，其主要目的是生产一种电路控制器，在该控制器中，由导电流体的旋转体以类似方式进行操作的独立安装的终端可以被封装在一个气密容器内。

The invention comprises features of construction by which this object is practically secured and certain improvements applicable to this and other analogous devices, as will be more fully hereinafter set forth.

本发明包括实际上确保该目的的结构特征和适用于该装置和其他类似装置的某些改进,这将在下文中更全面地阐述。

In the accompanying drawings, Figure 1 is vertical central section of the improved circuit-controller, and Fig. 2 is a top plan view of the same with the top or cover of the receptacle removed.

在附图中,图 1 是改进后的电路控制器的垂直中间截面图,图 2 是移除了容器的顶部或盖子的该电路控制器的俯视图。

The operative portions of the circuit-controlling mechanism are contained in a closed cylindrical receptacle A, of iron or steel, mounted on a spindle B in a suitable socket or support C to permit it to be freely and rapidly rotated. The socket C is secured to or forms a part of a base or stand D.

电路控制机械装置的操作部分被容纳在铁质或钢质的封闭圆筒形容器 A 中,该容器安装在合适的承口或支架 C 内的心轴 B 上,以允许其自由和快速地旋转。承口或支架 C 被固定到底座或支架 D 上或成为后者的一部分。

As a means of producing the proper rotation of the receptacle A, I have shown a field-magnet E, mounted on or secured to the base D, and an armature F, supported by a bracket G from the under side of the receptacle A. The same bracket also carries a series of commutator-segments H, upon which bear brushes I, these parts being arranged to constitute an electromagnetic motor with stationary field and rotating armature. It may be stated that any other suitable means may be employed to rotate the receptacle and the fluid.

作为让容器 A 适当旋转的一个措施,我已经展示了安装在或固定到基座 D 上的一块场磁体 E,以及由支架 G 从容器 A 的下侧支撑的电枢 F。相同的支架还携带一连串换向器分段 H,该换向器分段上倚靠着电刷 I,这些部件被布置成构成具有静态磁场和旋转电枢的电磁电动机。可以声明的是,可以使用任何其他合适的装置来旋转容器和流体。

In the spindle B and concentric with its axis is a spindle J in bearings specially constructed to reduce friction in order that the spindle J may be as little as possible influenced by the rotation of the main spindle and receptacle carried thereby. A suitable provision is made to oppose or prevent the rotation of the spindle J during the rotation of the receptacle. I have devised for this purpose the following:

在心轴 B 中并且与其轴线同心的是在轴承中的心轴 J,该轴承被专门构造成减少摩擦,以便心轴 J 可以尽可能少地受到主心轴的和它承载的容器的旋转的影响。在容器旋转期间,采取适当的措施来阻止或防止心轴 J 的旋转。为此,我设计了以下内容:

The spindle B is held by its bearings at an angle to the vertical, and a weight K is secured eccentrically to the spindle J and tends to hold the said spindle always in one position. The inclination of the axes of rotation necessary for this result may be substantially that shown and should not be materially greater, for the reason that it is especially advantageous to preserve that spindles and bearings as nearly as

practicable vertical on account of lesser friction and easier lubrication.

心轴 B 由其轴承保持成与竖直方向成一定角度，一个重物 K 被偏心地固定在心轴 J 上，并倾向于将所述心轴总是保持在一个位置。达到这一结果所需的旋转轴的倾斜度可以基本上如图所示，并且不应该明显比这更大，因为由于较小的摩擦和更容易的润滑，保持心轴和轴承尽可能接近竖直是特别有利的。

Attached to the spindle J or weight K is an insulated bracket L, carrying a standard or socket M, in which is mounted on antifriction-bearings a spindle N. Secured to this latter is a plate with radial arms O, from which depend vanes or blades P, with projections Q extending radially therefrom. A shield or screen R encloses the vanes, except on the side adjacent to the inner periphery of the receptacle A.

连接到心轴 J 或重物 K 的是一个绝缘支架 L，携带着支架或承口 M，在该支架中，一个心轴 N 被安装在滚动轴承上。被固定到心轴 N 的是具有径向臂 O 的板，叶片或桨叶 P 从该板悬垂，突出部 Q 从该板径向延伸。除了叶片与容器 A 的内周边相邻的一侧之外，护罩或屏蔽 R 围绕着叶片。

A small quantity of a conducting fluid S is placed in the receptacle, and in order to secure a good electrical connection between the vanes P and a terminal on the outside of the receptacle a small mercury-cup T, in metallic contact with the vanes through the bracket L and socket M, is secured to the weight K. A metal stud V, set in an insulated bolt W, projects into the cup T through a packed opening in its cover. One terminal of the circuit-controlling mechanism will thus be any part of the metal receptacle and the other the insulated bolt W. The apparatus may be connected up in circuit by connecting the wires of the circuit to a brush X, bearing on the bolt W, and to a binding-post Y in contact with the base D.

少量的导电流体 S 被放置在容器中，并且为了确保叶片 P 和容器外部的一个终端之间的良好电连接，通过支架 L 和承口 M 与叶片进行金属接触的小水银杯 T 被固定到重物 K 上。被固定在绝缘螺栓 W 中的一个金属螺柱 V 通过盖子上的被压紧的开口伸入到杯子 T 中。因此，电路控制机械装置的一个终端将是金属容器的任何部分，而另一个终端是绝缘螺栓 W。通过将电路的电线连接到倚靠在螺栓 W 上的电刷 X 和与底座 D 接触的接线柱 Y 上，可以将该装置连接到电路中。

To operate the apparatus, the receptacle is set in rotation, and as its speed increases the mercury or other conducting fluid which it contains is carried by centrifugal force up the sides of the inner wall, over which it spreads in a layer. When this layer rises sufficiently to encounter the projections Q on the blades or vanes P, the latter are set in rapid rotation, and the electrical connection between the terminal of the apparatus is thereby made and broken, it may be, with very great rapidity.

为了操作该设备，容器被设置成可旋转，并且随着其速度的增加，它所容纳的水银或其他导电流体被离心力携带到内壁的侧面上，在内壁上展开成一层水银。当该水银层上升到足以碰到桨叶或叶片 P 上的凸起 Q 时，叶片被设置成快速旋转，并且设备的终端之间的电连接由此以非常快的速度接通和断开。

The projections Q are preferably placed at different heights on the vanes P, so as to secure greater

certainty of good contact with the mercury film when in rapid rotation.

突起 Q 最好设置在叶片 P 上的不同高度处，以便在快速旋转时确保与水银膜良好接触的更大的确定性。

As to the forms of the circuit-controller heretofore referred to and upon which my present invention is an improvement the blades or vanes P may be regarded in a broad sense as typical of any device—such, for example, as a stelliform disk—which will be set and maintained in rotation by that of the receptacle. So, also, having regard to the feature of my invention which provides for maintaining such a device in operation in a receptacle which may be hermetically sealed, so as to be capable of containing an inert medium under pressure in which the makes and breaks occur and which medium is practically essential to a long-continued and economical operation of the device, I may employ other and widely-different means for opposing or preventing the rotation of the part carrying such vanes in the direction of the rotation of the receptacle and fluid.

至于迄今为止所提到的电路控制器的形式，并且我的本发明对其进行了改进，桨叶或叶片 P 可以在广义上被认为是任何装置的典型形式，例如星状盘，它将通过容器的旋转来设定和维持旋转。因此，也考虑到我的发明的特征，该特征提供了在被密封的一个容器中维持这种装置运行的方法，以便能够在压力下容纳一种惰性介质，在该压力下产生接通和断开，并且在该压力下介质对于该装置的长期持续和经济的运行在实际上是必要的，我可以采用其他的和迥然不同的装置来阻止或防止携带着这种叶片的部分在容器和流体的旋转方向上的旋转。

Having now described my invention, what I claim is—

现在描述了我的发明，我主张的是—

1. A circuit-controller comprising, in combination, a closed receptacle containing a fluid, means for rotating the receptacle, a support mounted within the receptacle, means for opposing or preventing its movement in the direction of rotation of the receptacle, and a conductor carried by said support and adapted to make and brake electric connection with the receptacle through the fluid, as set forth.

1、一种电路控制器，包括容纳流体的一个封闭容器；用于旋转该容器的装置；安装在容器内的一个支撑件；用于阻止或防止该支撑件在容器旋转方向上移动的装置；以及由所述支撑件携带的导体，该导体适于通过流体与容器建立和断开电连接，如前所述。

2. A circuit-controller comprising, in combination, a terminal capable of rotation and formed or provided with radiating contacts, a closed receptacle containing a fluid which constitutes the opposite terminal, means for rotating the receptacle, a support therein for the rotating terminal, and means for opposing or preventing the rotation of the support in the direction of the rotation of the receptacle, as set forth.

2、一种电路控制器，包括能够旋转并形成或配有辐射排列的触点的一个终端；容纳流体的一个封闭容器，该流体构成相对终端；用于旋转该容器的装置；该容器中的用于支撑旋转终端的支撑件；以及用于阻止或防止支撑件在容器旋转方向上旋转的装置，如前所述。

3. In a circuit-controller, the combination with a receptacle capable of rotation about an axis inclined to the vertical and containing a fluid which constitutes one terminal, a second terminal mounted within the receptacle, on a support capable of free rotation relatively to the receptacle, and a weight eccentric to the axis of rotation of the support for said terminal for opposing or preventing its movement in the direction of the rotation of the said receptacle, as set forth.

3、在一个电路控制器中，存在一个组合，包括：构成终端的一个容器，该容器能够围绕倾斜于垂直方向的轴旋转，并容纳流体；第二终端被安装在容器内的能够相对于所述容器自由旋转的支撑件上；以及一个偏心于所述终端支撑件的旋转轴的重物，该重物用于阻止或防止该支撑件在所述容器的旋转方向上的运动，如前所述。

4. The combination with a receptacle mounted to revolve about an axis inclined to the vertical, of a spindle within the receptacle and concentric with its axis, a weight eccentric to the spindle, and a terminal carried by the said spindle, and adapted to be rotated by a body of conducting fluid contained in the receptacle when the latter is rotated, as set forth.

4、存在一个组合，包括：被安装成围绕倾斜于竖直方向的轴进行旋转的一个容器；位于容器内并与容器轴线同心的心轴；偏心于心轴的重物以及由所述心轴携带的终端，并且当容器被转动时，该终端适于由被包含在容器中的导电流体推动旋转，如前所述。

5. The combination with a receptacle mounted to rotate about an axis inclined to the vertical, a spindle within the receptacle and concentric with its axis, a weighted arm attached to said spindle, a bracket or arm also secured to said spindle, a rotary terminal with radiating contact arms or vanes mounted on said bracket in position to be rotated by a body of conducting fluid contained in said receptacle when said fluid is displaced by centrifugal action, as set forth.

5、存在一个组合，包括：被安装成围绕倾斜于竖直方向的轴线旋转的一个容器；位于容器内并与其轴线同心的心轴；连接到所述心轴上的配重臂；被固定到所述心轴上的支撑件或臂；一个旋转终端，它具有被安装在所述支撑件上的辐射状排列的接触臂或叶片，当所述流体通过离心作用移动时，所述的辐射状排列的接触臂或叶片被所述容器中的导电流体推动旋转，如前所述。

NIKOLA TESLA.

尼古拉·特斯拉

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No. 609,247.

Patented Aug. 16, 1898.

N. TESLA.
ELECTRIC CIRCUIT CONTROLLER.

(Application filed Mar. 12, 1898.)

(No Model.)

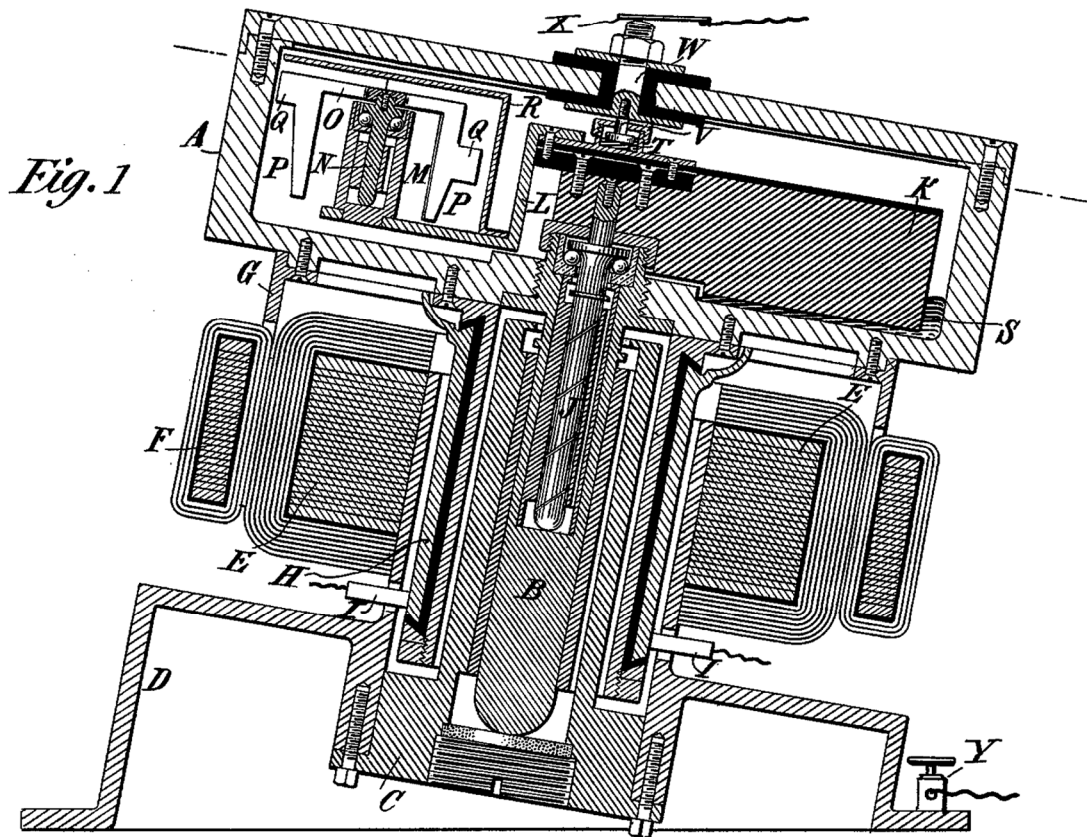
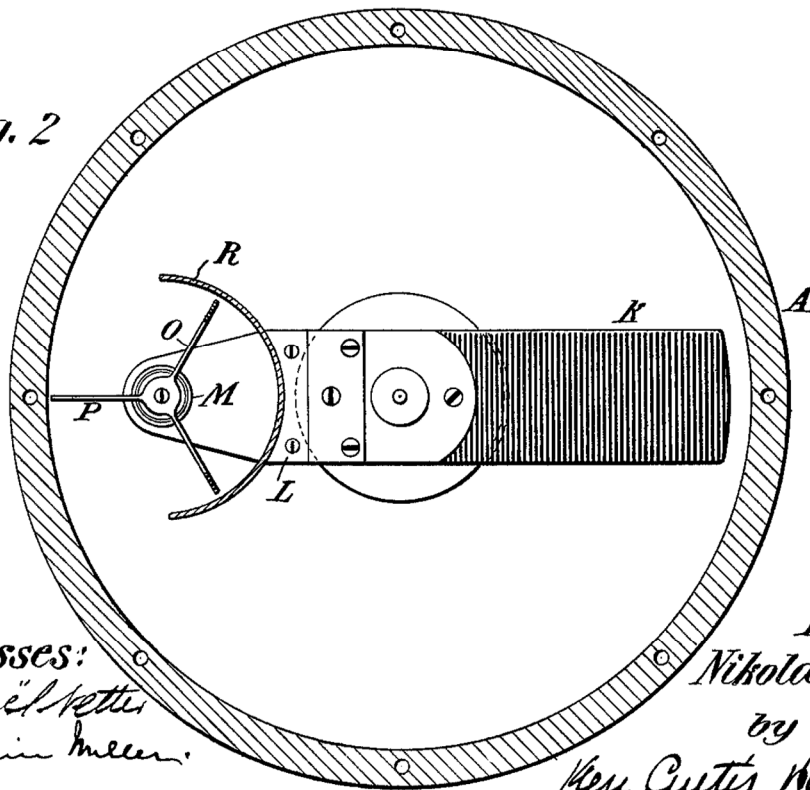


Fig. 2



Witnesses:
Raphaël Petter
Benjamin Meier

Inventor
Nikola Tesla
by
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ELECTRIC-CIRCUIT CONTROLLER.

电路控制器

NIKOLA TESLA, OF NEW YORK, N. Y.

纽约州纽约市的尼古拉·特斯拉

SPECIFICATION forming part of Letters Patent No. 609,248, dated August 16, 1898.

Application filed March 12, 1898. Serial No. 673,559. (No model.)

该说明书形成了颁发于 1898 年 8 月 16 日编号为 609,248 的专利证书的一部分。

该申请于 1898 年 3 月 12 日提交。序列号为 673,559。(没有模型)

To all whom it may concern:

致所有相关人士:

Be it known that I, NIKOLA TESLA, of the borough of Manhattan, in the city, county, and State of New York, have invented certain new and useful Improvements in Circuit-Controllers, of which the following is a specification, reference being had to the drawings accompanying and forming a part of the same.

众所周知，我，尼古拉·特斯拉，一名美国公民，居住在纽约州纽约郡纽约市的曼哈顿区，在电路控制器方面已经发明了某些新的和有用的改进，以下是该发明一个说明书，必须参考随附的图纸，它已形成了该说明书的一部分。

In previous applications filed by me, notably in Serial No. 660,518, filed December 2, 1897, and others, I have shown and described various forms of electric-circuit controllers in which a conducting fluid is used for one or both of the terminals. These contrivances, while applicable generally as a means of making and breaking an electric circuit with great rapidity, were devised by me more especially for use in my now well-known system of electrical conversion by means of condenser-discharges and for this reason have been designed with especial reference to the peculiar and exceptional conditions which obtain in such systems. My present invention is an improvement in circuit-controllers of this kind, and in order that the object and nature of the improvement may be more readily understood and appreciated I may refer briefly to the more essential characteristics of the devices described before upon which the present improvement is based. As it was primarily essential that these controllers be capable of making and breaking the circuit at very rapid rate and as such a result could not be secured practically or economically by any of the ordinary devices employing rigid contacts or terminals I was led to invent apparatus in which the circuit connections were established and broken between a rigid terminal and a fluid conductor or between two fluid conductors in the form of jets or streams. In the forms of apparatus employing a rigid or solid conductor as one terminal and a fluid as the other the makes and breaks of course occur always between a solid and a fluid terminal, and although the operative parts of my improved circuit-controllers were usually confined in air or gas tight receptacles and in an inert medium, both for the purpose of improving their action and preventing deterioration of the terminals,

there is still a liability to wear of the rigid or solid terminal.

在我以前提交的申请中，特别是在 1897 年 12 月 2 日提交的序列号为 660,518 的申请和其他申请中，我已经展示和描述了各种形式的电路控制器，在这些控制器中，一种导电流体被用作一种终端或两种终端。这些奇巧的发明，虽然一般适用于快速接通和断开电路，但我设计的更特别的是在我现在众所周知的通过电容器放电的电气转换系统中所使用的，因此设计时特别参考了在这种系统中获得的奇特和异常的条件。我的发明是对这种类型的电路控制器的一项改进，为了更容易理解和认识这种改进的目的和性质，我可以简要地提及本改进所基于的前述装置的更基本的特征。由于这些控制器能够以非常快的速度接通和断开电路是至关重要的，并且这样的结果在事实上或经济上不能通过任何使用刚性触点或终端的普通装置来保证，因此我被引导发明了一种装置，该装置中的电路连接的建立和断开是在一个刚性终端和一种导电流体之间，或者以射流或流束的形式在两种导电流体之间。在采用刚性或固体导体作为一个终端而采用流体作为另一个终端的装置中，接通和断开当然总是发生在固体终端和流体终端之间，并且尽管我的改进后的电路控制器的运行部件通常被限制在密封或气密的容器中和惰性介质中，两者都是为了改进它们的作用和防止终端的劣化，但是仍然存在刚性或固体终端磨损的倾向。

Under certain conditions, as when the circuit-controller is operated from a source of direct current, the deterioration of the solid terminal may be materially reduced by connecting it to the negative pole of the generator. Nevertheless, there will be always a slow wearing away of the metal, which to overcome entirely in a novel manner is the object of my present improvement. To do this, I effect the closure of the circuit through two parts of conducting fluid; but instead of breaking the circuit by the movement of these two parts or terminals, as before, I separate them periodically by the interposition of an insulator which is preferably solid and refractory. For example, I provide a plate or disk with teeth or projections—preferably of glass, lava, or the like—which are caused by the rotation of the disk to pass through the fluid conductor, jet, or whatever it may be, and thus effect a make and break of the circuit.

在某些条件下，当电路控制器由直流电源运行时，固体终端的劣化可以通过将其连接到发电机的负极而大大减少。然而，金属总是会慢慢磨损，以一种新颖的方式完全克服这种劣化是我目前改进的目标。为了做到这一点，我利用两部分导电流体实现电路的闭合；但不是像以前那样，通过移动这两个部分或两个终端来断开电路，而是通过插入一个绝缘体来周期性地将它们分开，绝缘体最好是固体的和耐火的。例如，我提供了一个带有齿或突起的板或盘，最好为玻璃、火山岩或类似物，这些齿或突起由盘的旋转带动，以穿过导电的流体、射流或任何可能的东西，从而实现电路的接通和断开。

By means of such a device the breaks always occur between fluid terminals, and hence the deterioration and consequent impairment of the qualities of the apparatus are avoided.

通过这种装置，断路总是发生在流体终端之间，因此避免了装置质量的劣化和随之而来的损害。

A preferred form of my improved circuit-controller is illustrated in the accompanying drawing, which shows a central vertical section of the same.

在附图中展示了我的改进后的电路控制器的首选形式，该图展示了该电路控制器的中央垂直

截面。

The two terminals are contained in an air-tight receptacle A, of iron or steel, which is mounted on a spindle B in a suitable socket or support C, so as to rotate freely. The socket C is secured to or forms part of a base or stand D. Any suitable means may be employed for effecting the rotation of the receptacle, and in illustration of a convenient and practicable means for this purpose I have shown an armature E, secured to a cylindrical extension of the receptacle that surrounds the socket C, and a field-magnet F, which is supported independently and is stationary. The armature-coils are connected with the segments S of a commutator on which bear brushes G.

两个终端被容纳在铁质或钢质的一个气密容器 A 中，该容器被安装在合适的承口或支撑件 C 内的心轴 B 上，以便能自由旋转。承口或支撑件 C 被固定到底座或支架 D 上或形成后者的一部分。可以采用任何合适的装置来实现该容器的旋转，并且为了说明用于此目的的方便可行的装置，我已经展示了电枢 E 和场磁体 F，电枢 E 被固定到所述容器的圆筒形延伸部上，该延伸部围绕着承口 C，场磁体 F 被独立支撑并且是静态的。电枢线圈与一个换向器的分段 S 相连，电刷 G 倚靠在该分段上。

In the spindle B and concentric with its axis is a spindle H, supported on ball-bearings or otherwise arranged to have a free movement of rotation relatively to the spindle B, so as to be as little as possible influenced by the rotation of the latter.

在心轴 B 中并且与心轴 B 的轴线同心的是心轴 H，它被支撑在滚珠轴承上或者以其他方式布置成相对于心轴 B 自由旋转运动，以便尽可能少地受心轴 B 旋转的影响。

Any convenient means is provided to oppose or prevent the rotation of the spindle H during the rotation of the receptacle. In the particular arrangement here shown for this purpose a weight or weighted arm J is secured to the spindle H and eccentrically to the axis of the latter, and as the bearing for the spindle B holds the same at an angle to the vertical this weight acts by gravity to hold the spindle H stationary.

在容器旋转过程中，提供任何方便的措施来阻止或防止心轴 H 的旋转。在此处展示的用于此目的的特定布置中，一个重物或配重臂 J 被固定到心轴 H 上，并且偏心于心轴 H 的轴线，并且由于心轴 B 的轴承将心轴 B 保持与竖直方向成一定角度，该重物通过重力作用保持心轴 H 处于静止。

Secured to the top or cover of the receptacle A by a stud K, which passes through an insulating-bushing in said cover and is held by a nut L, is a circular disk M, of conducting material, preferably iron or steel, having its edge turned downwardly and then inwardly to provide a peripheral trough on the under side of the disk.

由导电材料（最好是铁或钢）制成的圆盘 M 通过螺柱 K 固定到容器 A 的顶部或盖子上，螺柱 K 穿过所述盖子中的一个绝缘衬套，该衬套由螺母 L 夹持，圆盘 M 的边缘向下然后向内翻转，以在圆盘的下侧提供周沿槽。

To the under side of the disk M is secured a second disk N, having downwardly-enclosed peripheral

projections O O, of insulating and preferably refractory material, in a circle concentric with the disk M.

在盘 M 的下侧固定有第二个盘 N，它具有向下封闭的外周突起 O、O，这些突起由绝缘材料并且最好为耐火材料制成，处于与盘 M 同心的圆中。

A tube or duct P is mounted on the spindle H or the weight J and is so arranged that the orifice at one end is directed outwardly toward the trough of the disk M, while the other lies close to the inner peripheral wall of the receptacle, so that if a quantity of mercury or other conducting fluid be placed in the receptacle and the latter rotated the tube or duct P, being held stationary, will take up the fluid which is carried by centrifugal action up the side of the receptacle and deliver it in a stream or jet against the trough or flange of the disk M or against the inner surfaces of the projections O of disk N, as the case may be.

一条管或导管 P 被安装在心轴 H 或重物 J 上，并且被布置成使得一端处的开孔向外指向盘 M 的槽，而另一端靠近容器的内周壁，这样，如果一定量的水银或其它导电流体被放置在容器中，并且后者被转动，被保持静止的管或导管 P，将带走由离心作用而带到容器侧面上的流体，并以流束或射流的形式将其射向圆盘 M 的槽或凸缘上，或者射向到圆盘 N 的突起 O 的内表面上，视情况而定。

Obviously, since the two disks M and N rotate with respect to the jet or stream of fluid issuing from the duct P, the electrical connection between the receptacle and the disk M through the fluid will be completed by the jet when the latter passes to the disk M between the projections O and will be interrupted whenever the jet is intercepted by the said projections.

显然，由于两个圆盘 M 和 N 相对于从导管 P 流出的射流或流束旋转，当射流到达突出部 O 之间的盘 M 时，容器和盘 M 之间的电连接将通过流体由射流完成，并且每当射流被所述突出部截断时，电连接将被中断。

The rapidity and the relative duration of the makes and breaks is determined by the speed of rotation of the receptacle and the number and width of the intercepting projections O.

接通和断开的速度和相对持续时间由容器的旋转速度和拦截凸起 O 的数量和宽度决定。

By forming that portion of the disk M with which the jet makes contact as a trough, which will retain when in rotation a portion of the fluid directed against it, a very useful feature is secured. The fluid under the action of centrifugal force accumulates in and is distributed along the trough and forms a layer over the surface upon which the jet impinges. By this means a very perfect contact is always secured and all deterioration of the terminal surfaces avoided.

通过将射流与盘 M 接触的部分形成为槽，当旋转时，该槽将保持一部分流体抵靠着它，确保了非常有用的一个特征。在离心力的作用下，流体积聚在槽中并沿着槽分布，并在射流冲击的表面上形成一层导电流体。通过这种方式，总是确保非常完美的接触，并且避免终端表面的所有劣化。

The principle of interrupting the circuit by intermittently passing an insulator through a fluid conductor

may be carried out by many specifically-different forms of apparatus, and in this respect I do not limit myself to the particular form herein shown.

通过使绝缘体间歇地穿过流体导体来中断电路的原理可以通过许多具体不同形式的装置来实现，在这方面，我并不将自己局限于这里所示的特定形式。

What I claim is—

我主张的是—

1. In an electrical-circuit controller, the combination with a conductor forming one of the terminals, of means for maintaining a jet or stream of conducting fluid forming the other terminal, and directing it against said conductor, and a body adapted to be intermittently moved through and to intercept the jet or stream, as set forth.

1、在一个电路控制器中，存在一个组合，包括：形成一个终端的导体；用于保持形成另一个终端的导电流体的射流或流束；并将该射流或流束引向所述导体的装置；以及适于间歇地被移动穿过并拦截射流或流束的主体，如上所述。

2. In an electrical-circuit controller, the combination with a rigid terminal, of means for directing against such terminal a jet or stream of conducting fluid in electrical connection with the other terminal, and a body adapted to be intermittently moved through and to intercept the jet or stream, as set forth.

2、在一个电路控制器中，存在一个组合，包括：一个刚性终端；用于引导导电流体的射流或流束冲向该刚性终端，并将其与另一终端连接的装置；以及适于间歇地被移动穿过并拦截射流或流束的主体，如上所述。

3. In an electrical-circuit controller, the combination with a rigid terminal, of means for directing against such terminal a jet or stream of conducting fluid in electrical connection with the other terminal, a body having a series of radial projections and means for rotating the same so that the said projections will intermittently intercept the stream or jet, as set forth.

3、在一个电路控制器中，存在一个组合，包括：一个刚性终端，用于引导导电流体的射流或流束冲向该刚性终端，并将该射流或流束与另一终端连接的装置；具有一连串径向突起的主体和用于旋转该主体的装置，使得所述突起将间歇地拦截射流或流束，如前所述。

4. In a circuit-controller, the combination with a rotary conductor forming one terminal, means for directing against such terminal a jet or stream of conducting fluid in electrical connection with the other terminal, and a body with spaced projections mounted to rotate in a path that intercepts the jet or stream of fluid, as set forth.

4、在一个电路控制器中，存在一个组合，包括：形成一个终端的一个旋转导体；用于引导导电流体的射流或流束射向该终端，并将该射流或流束与另一终端连接的装置；以及具有被间隔开的突出部的主体，该突出部被安装成在能截断流体射流或流束的路径中旋转，如前所述。

5. In a circuit-controller, the combination with a rotary conductor forming one terminal, and means for directing intermittently against such terminal a jet or stream of fluid in electrical connection with the other terminal, the part of said rotary conductor upon which the jet or stream impinges being formed so as to retain, by centrifugal force, a portion of the fluid directed against it, as set forth.

5、在电路控制器中，存在一个组合，包括：形成一个终端的一个旋转导体，用于引导导电流体的射流或流束射向该终端，并将该射流或流束与另一终端连接的装置；射流或流束所冲击的所述旋转导体的那一部分通过离心力使得一部分流体抵靠着它，如前所述。

6. The combination of the receptacle, the conducting-disk secured within it, the insulated disk with peripheral projections and the stationary tube or duct for directing a stream or jet of conducting fluid toward the conducting-disk and across the path of the projections O, as set forth.

6、存在一个组合，包括：一个容器；固定在该容器中的导电盘；具有外围突起的绝缘盘和用于将导电流体的射流或流束引导至导电盘并穿过突起 O 的旋转路径的静态管或导管，如前所述。

7. The combination of the receptacle, the conducting-disk with a peripheral trough-shaped flange, the insulated disk with peripheral projections O, and the stationary tube or duct for directing a stream or jet of conducting fluid into the trough-shaped flange of the conducting-disk and across the path of the projections O, as set forth.

7、存在一个组合，包括：一个容器；具有一个外围槽形凸缘的导电盘；具有外围突起 O 的绝缘盘；以及用于将导电流体的射流或流束引导至导电盘的槽形凸缘并穿过突起 O 的旋转路径的静态管或导管，如前所述。

NIKOLA TESLA.

尼古拉·特斯拉

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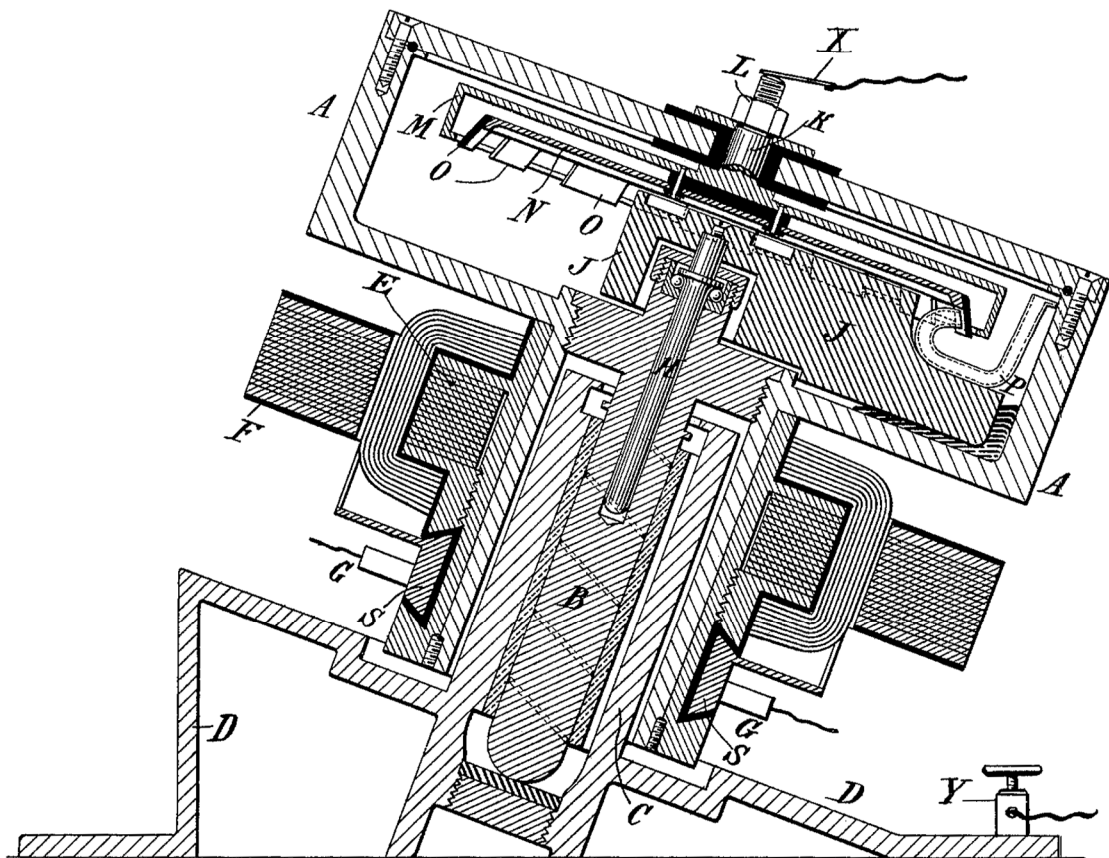
No. 609,248.

Patented Aug. 16, 1898.

N. TESLA.
ELECTRIC CIRCUIT CONTROLLER.

(Application filed Mar. 12, 1898.)

(No Model.)



Witnesses:
Raphaël Ketter
Benjamin Miller

Nikola Tesla, Inventor
by *Wm. Curtis Wase* Att'ys.

ELECTRIC-CIRCUIT CONTROLLER.

电路控制器

NIKOLA TESLA, OF NEW YORK, N. Y.

纽约州纽约市的尼古拉·特斯拉

SPECIFICATION forming part of Letters Patent No. 609,249, dated August 16, 1898.

Application filed March 12, 1898. Serial No. 673,560. (No model.)

该说明书形成了颁发于 1898 年 8 月 16 日编号为 609,249 的专利证书的一部分。

该申请于 1898 年 3 月 12 日提交。序列号为 673,560。(没有模型)

To all whom it may concern:

致所有相关人士:

Be it known that I, NIKOLA TESLA, of the borough of Manhattan, in the city, county, and State of New York, have invented certain new and useful Improvements in Electrical-Circuit Controllers, of which the following is a specification, reference being had to the drawing accompanying and forming a part of the same.

众所周知，我，尼古拉·特斯拉，一名美国公民，居住在纽约州纽约郡纽约市的曼哈顿区，在电路控制器方面已经发明了某些新的和有用的改进，以下是该发明一个说明书，必须参考随附的图纸，它已形成了该说明书的一部分。

The present application is based upon improvements in electrical-circuit controllers of the kind heretofore invented by me and described in previous applications, notably in an application filed December 2, 1897, Serial No. 660,518. The chief distinguishing features of these devices are the use of a conducting fluid for one or both of the terminals under conditions which permit of a very rapid succession of makes and breaks and a construction or arrangement which allows the enclosing of the terminals in an air-tight receptacle in which an inert medium may be maintained. My efforts to meet the practical requirements of apparatus of this kind have led me to adopt expedients and to invent mechanisms entirely novel in such devices. For example, in order to effect a rapidly-intermittent contact between two terminals by the use of a jet or jets in a closed receptacle it is obviously necessary to employ special means which will operate to hold one part of the apparatus stationary while the other rotates or to rotate both the essential parts or terminals in opposite directions or, as the case may be, in the same direction at different speeds.

本申请是基于对迄今为止由我发明的并在以前的申请中描述的电路控制器的改进，特别是在 1897 年 12 月 2 日提交的序列号为 660,518 的申请中。这些装置的主要区别特征是在允许非常快速的连续接通和断开的条件下，将导电流体用于一种或两种终端，以及允许将终端密封在气密容器中的结构或布置，在该容器中可以保持一种惰性介质。我为满足此类设备的实际要求而做出的努力使我采用了权宜之计，并在此类设备中发明了全新的机械装置。例如，为

了通过在封闭的容器中使用一个或多个射流来实现两个终端之间的快速间歇接触,显然需要使用特殊的装置来保持设备的一部分静止,而另一部分旋转,或者以相反的方向旋转两个最重要的部分或终端,或者视情况而定,以不同的速度在相同的方向上旋转。

The present invention is embodied in a device for securing the proper relative movement of the two parts or terminals of the circuit-controller and involves two salient features of novelty, one that it provides for maintaining in a rotating receptacle a stationary jet or jets which by impinging on a rigid conductor maintain the latter in rotation, thereby securing the requisite rapidly-intermittent contact between the two, and the other that it utilizes the rotation of such rigid conductor as a means for opposing or preventing the movement of its own supports in the direction of rotation of the receptacle, thereby securing, among other things, an approximately constant relative movement between the parts, a feature which in devices of this kind is often very desirable.

本发明体现在一种用于确保电路控制器的两个部件或终端的适当相对运动的装置中,并且包括两个突出的新颖性特征,一个特征是它提供了在旋转容器中保持一个或多个静止射流,该射流通过撞击刚性导体来保持刚性导体旋转,从而确保两者之间必要的快速间歇接触,另一方面,它利用这种刚性导体的旋转作为对抗或防止其自身支撑件在容器旋转方向上运动的手段,从而尤其确保部件之间的近似恒定的相对运动,这在这种类型的装置中是非常理想的特征。

In the drawing hereto annexed I have illustrated the preferred form of apparatus which I have devised for carrying out these improvements. The figure is a central vertical cross-section of a circuit-controller.

在附图中,我已经说明了我为实现这些改进而设计的装置的优选形式。该图是电路控制器的中心垂直截面图。

A designates a receptacle, usually of iron or steel and mounted in any suitable manner, as by trunnions B B, having bearings in standards C C, so as to be capable of rapid rotation about a horizontal axis.

A 表示一个容器,通常由铁或钢制成,并以任何合适的方式安装,如通过耳轴 B B,它具有在立柱 C C 中的轴承,以便能够使容器 A 绕水平轴快速旋转。

In the particular form of device under consideration the receptacle is divided into two parts insulated by a washer D and held together by insulated bolts E with nuts F. These two parts are electrically connected, respectively, with the two terminals of the apparatus, as hereinafter described, and by means of brushes X Y, bearing at any suitable points on the two parts of the receptacle, the circuit-controller is connected with the wires of a circuit.

在所考虑的装置的特定形式中,该容器被分成两部分,由一个垫圈 D 绝缘,并由绝缘螺栓 E 和螺母 F 固定在一起。如下文所述,这两个部件分别与装置的两个终端电连接,并且通过倚靠在容器的两个部分的任何合适的点上的电刷 X Y,电路控制器与电路的导线进行连接。

Any convenient means may be employed to rotate the receptacle; but a simple way to effect this is to surround the same with a field-magnet G and to make the receptacle itself the armature of an electric motor or else to secure to it armature-cores, as H.

可以采用任何方便的措施来旋转容器;但来实现这一点的一个简单的方法是用一个场磁体 G 包围它, 使容器本身成为电动机的电枢, 或者将该容器固定到电枢铁芯上, 如 H。

A body I is supported by trunnions J, having bearings in the ends of the receptacle and concentric with the axis of rotation of the same. The weight of the body I being eccentric to this axis tends to oppose its turning about the axis when the receptacle is rotated.

一个主体 I 由耳轴 J 支撑, 该耳轴在容器的端部具有轴承, 并且与容器的旋转轴同心。当容器旋转时, 偏心于该轴线的主体 I 的重量倾向于抵抗其自身围绕该轴线的转动。

Upon the body or support I, but insulated therefrom, is secured a vertical standard K, in which there is a freely-rotatable spindle L, carrying a disk M, with radial arms inclined to the plane of the disk, so as to form vanes N. Arms O P are also secured to the body I and are formed with or carry at their ends ducts or tubes Q, with one end directed toward and opening upon the vanes N and the other end close to the inner wall of the receptacle and opening in the direction opposite to that of the rotation of the receptacle.

一个垂直的立柱 K 被固定在主体或支撑件 I 上, 但是与后者绝缘, 立柱 K 中有可自由旋转的心轴 L, 它携带了一个圆盘 M, 具有倾斜于圆盘平面的径向排列的臂, 从而形成叶片 N。臂 OP 也被固定到主体 I 上, 并且在臂的端部形成或携带有导管或管道 Q, 其一端朝向叶片 N 并在叶片 N 上方开口, 另一端靠近容器的内壁并在与容器旋转方向相反的方向上开口。

A suitable quantity of mercury R is placed in the receptacle before the latter is sealed or closed.

在容器密封或关闭之前, 将适量的水银 R 放入容器中。

The operation of the device is as follows: The receptacle is started in rotation, and as it acquires a high velocity the mercury or other conducting fluid R is caused by centrifugal action to distribute itself in a layer over the inner peripheral surface of the receptacle. As the tubes or ducts Q do not take part in the rotation of the fluid, being held at the start by the weighted body I, they take up the mercury as soon as it is carried to the points where the ducts open and discharge it upon the vanes of the disk M. By this means the disk is set in rapid rotation, establishing the contact between the two sides of the receptacle which constitute the two terminals of the circuit-controller whenever the two streams or jets of fluid are simultaneously in contact with the vanes, but breaking the contact whenever the jets discharge through the spaces between the vanes. The chief object of employing more than one insulated jet is to secure a higher velocity of approach and separation, and in respect to the number of jets thus employed the device may be obviously modified as desired without departure from the invention. The disk M, having acquired a very rapid rotation, operates to prevent by gyrostatic action any tendency of the body I to rotate or oscillate, as such movement would change the plane of rotation of the disk. The movement of the parts, therefore, and the operation of the device as a whole are very steady and uniform, and a material practical advantage is thereby secured. The speed of the disk will be chiefly dependent on the velocity of the streams and pitch of the blades, and it is of course necessary in order to produce a constant speed of rotation of the disk that the velocity of the streams be constant. This is accomplished by rotating the receptacle with a constant speed; but when this is impracticable and the uniformity of motion of the disk very desirable I resort to special means to secure this result, as by providing

overflowing-reservoirs V V, as indicated by dotted lines, from which the fluid issues upon the vanes with constant velocity, though the speed of the receptacle may vary between wide limits.

该装置的操作如下：容器开始旋转，当它获得一个高速度时，通过离心作用使水银或其它导电流体 R 在容器的内周表面上分布成一层流体。因为管或导管 Q 不参与流体的旋转，在开始时被配重体 I 保持静止，所以一旦水银被运送到导管开口的位置，导管就带走水银并将其排放到圆盘 M 的叶片上。通过这种方式，圆盘被设置成快速旋转，每当两股流束或射流同时与叶片接触时，在构成电路控制器的两个终端的容器两侧之间建立了接触，但是每当射流通过叶片之间的空间排出时，接触就断开了。使用一个以上被隔离的射流的主要目的是确保更高的接近速度和分离速度，并且关于如此使用的射流的数量，该装置可以明显地根据需要进行修改，而不背离本发明。已经获得非常快速的旋转的盘 M，通过陀螺定向作用来防止物体 I 旋转或摆动的任何趋势，因为这种运动将改变盘的旋转平面。因此，部件的运动和装置的整体运行是非常稳定和均匀的，从而确保了材料的实用优势。圆盘的速度将主要取决于流束的速度和叶片的间距，当然，为了使圆盘的旋转速度恒定，流的速度也必须恒定。这是通过以恒定速度旋转容器来实现的；但是当这是不可行的并且非常期望得到盘的运动的均匀性时，我诉诸于特殊的手段来确保这一结果，例如通过提供溢流池 V V，如虚线所示，流体从该溢流池 V V 以恒定的速度流出到叶片上，尽管容器的速度可以在很宽的范围内变化。

It may be stated that the jets can be produced in any other known ways and that they may be utilized in any desired manner to produce rotation of the disk.

可以说，射流可以以任何其他已知的方式产生，并且它们可以以任何期望的方式用于产生圆盘的旋转。

Having now described my invention, what I claim is—

现在描述了我的发明，我主张的是—

1. The combination in a circuit-controller with a closed rotary receptacle, of a rigid conductor mounted within the same and through which the circuit is intermittently established, and means for directing a jet or stream of a fluid which is contained in the receptacle, against the said body so as to effect its rotation independent of the receptacle, as set forth.

1、在一个电路控制器中，存在一个组合，包括：一个封闭的旋转容器；安装在容器内的一个刚性导体；并且电路控制器通过该导体间歇地建立电路；用于引导被容纳在容器中的流体的射流或流束射向所述主体以实现该主体独立于容器的旋转的装置，如前所述。

2. In an electric-circuit controller, the combination of a closed rotary receptacle, a conducting body therein adapted to be rotated independently of the receptacle by the impingement thereon of a jet or stream of conducting fluid, and means for maintaining such a jet and directing it upon the said conductor, as set forth.

2、在一个电路控制器中，存在一个组合，包括：一个封闭的旋转容器；其中的导体适于通过导电流体的射流或流束在该导体上的冲击而产生独立于容器的旋转；以及用于维持这种射流并将其引导到所述导体上的装置，如前所述。

3. In a circuit-controller, the combination with a rotary receptacle of a body or part mounted within the receptacle and concentrically therewith, a conducting-terminal supported by said body and capable of rotation in a plane at an angle to the plane of rotation of the receptacle so as to oppose, by gyrostatic action, the rotation of the support, and means for directing a jet of conducting fluid against the said terminal, as set forth.

3、在一个电路控制器中，存在一个组合，包括：一个旋转容器；被安装在该容器内并与其同心的主体或部件；由所述主体支撑的一个导电终端，该终端能够在与容器的旋转平面成一定角度的平面内旋转，从而通过陀螺定向作用对抗支撑件的旋转，以及用于引导导电流体的射流射向所述终端的装置，如前所述。

4. In a circuit-controller, the combination with a rotary receptacle of a support for a conductor mounted thereon concentrically with the receptacle and a gyrostatic disk carried by the support and adapted, when rotating, to oppose its movement in the direction of rotation of the receptacle, as set forth.

4、在一个电路控制器中，存在一个组合，包括：一个旋转容器；用于支撑一个导体的支撑件，该导体被安装在该容器上且与后者同心；由该支撑件承载的一个陀螺盘，当该陀螺盘旋转时，它适于抵抗自身在容器旋转方向上的运动，如前所述。

5. In a circuit-controller, the combination with rotary receptacle containing a conducting fluid, a support mounted within the receptacle, means for opposing or preventing its movement in the direction of rotation of the receptacle, one or more tubes or ducts carried thereby and adapted to take up the fluid from the rotating receptacle and discharge the same in jets or streams, and a conductor mounted on the support and adapted to be rotated by the impingement thereon of said jet or jets, as set forth.

5、在一个电路控制器中，存在一个组合，包括：容纳导电流体的旋转容器；被安装在容器内的一个支撑件；用于阻止或防止该支撑件在容器旋转方向上运动的装置；一个或多个由该容器携带的管或导管，适于带走流体并以射流或流束的形式射出流体；以及安装在支撑件上的导体，适于通过所述一个或多个射流在其上的冲击而旋转，如前所述。

6. The combination in a circuit-controller of a rotary receptacle, one or more tubes or ducts and a support therefor capable of rotation independently of the receptacle, a conductor mounted on said support in a plane at an angle to that of rotation of the receptacle, and adapted to be maintained in rotation by a jet of fluid taken up from the receptacle by and discharged upon it from the said tube or duct, when the receptacle is rotated.

6、在一个电路控制器中，存在一个组合，包括：一个旋转容器；一个或多个管或导管以及能够独立于容器进行旋转的一个支撑件；被安装在所述支撑件上的一个导体，所述导体位于与容器旋转的平面成一定角度的平面内，当容器旋转时，所述导体适于通过所述管或导管从容器中吸取并排放到其该导体的流体射流来保持旋转。

7. The combination with a rotary receptacle of one or more tubes or ducts, a holder or support therefore mounted on bearings within the receptacle, which permit of a free relative rotation of said receptacle and holder, a disk with a bearing on the said holder and having its plane of rotation at an angle to that of the receptacle, the disk being formed or provided with conducting-vanes, upon which a jet of

conducting fluid, taken up by the tube or duct from the receptacle when in rotation, is directed.

7、在一个电路控制器中，存在一个组合，包括：一个旋转容器；一个或多个管或导管；安装在容器内的轴承上的支架或支撑件，该轴承允许所述容器和支架的自由相对地旋转；在所述支架上具有轴承的一个圆盘，其旋转平面与容器的旋转平面成一角度，该盘形成或设置有导电叶片，当处于旋转时由管或导管从容器带走的导电流体，其射流被引导到该叶片上。

NIKOLA TESLA.

尼古拉·特斯拉

Witnesses:

M. LAWSON DYER,

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见证人:

M.劳森·戴尔、G. W.玛特林。

No. 609,249.

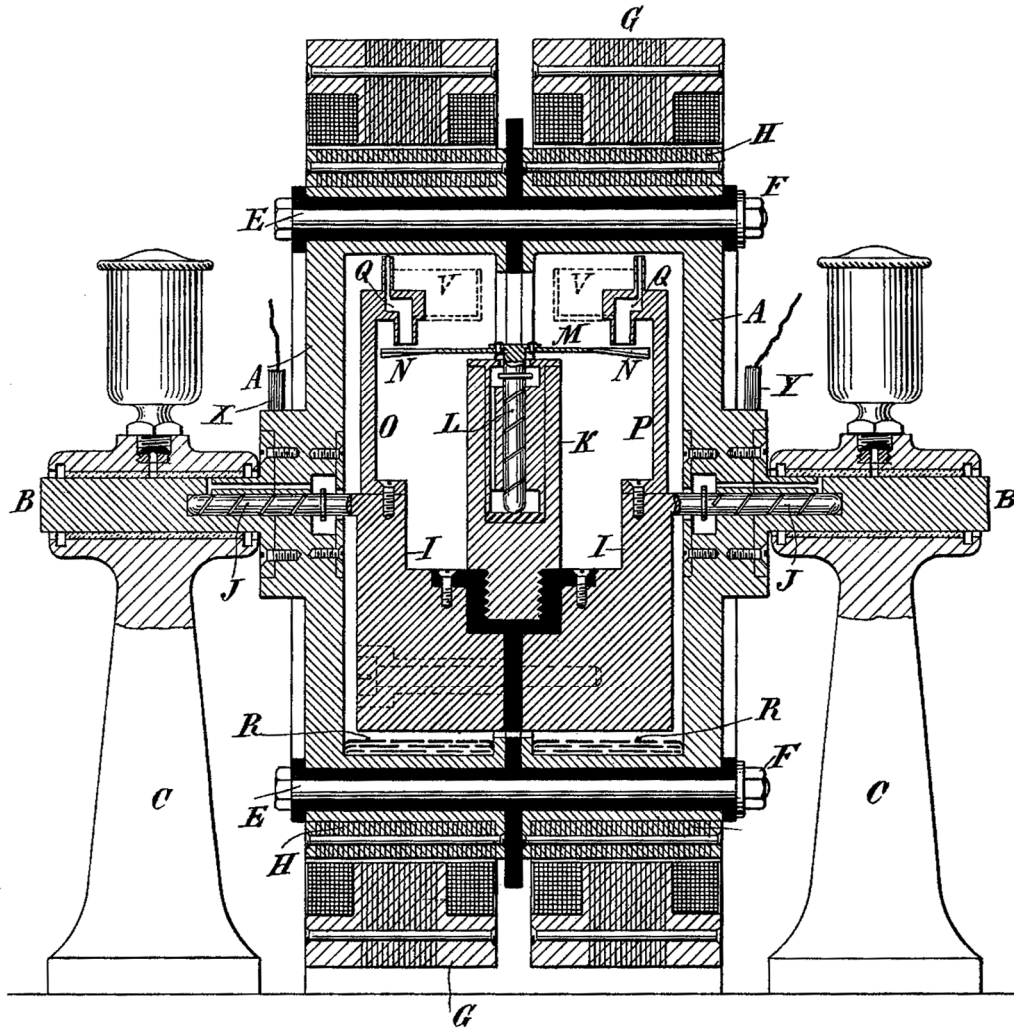
Patented Aug. 16, 1898.

N. TESLA.

ELECTRIC CIRCUIT CONTROLLER.

(Application filed Mar. 12, 1898.)

(No Model.)



Witnesses:
Raphaël Ketter
Benjamin Miller.

Nikola Tesla, Inventor
by Ken Curtis Hage Attyys

ELECTRICAL IGNITER FOR GAS- ENGINES.

用于燃气发动机的电点火器

NIKOLA TESLA, OF NEW YORK, N. Y

纽约州纽约市的尼古拉·特斯拉

SPECIFICATION forming part of Letters Patent No. 609,250, dated August 16, 1898.

Application filed February 17, 1897. Renewed June 15, 1898. Serial No. 683,524. (No model.)

该说明书形成了颁发于 1898 年 8 月 16 日编号为 609,250 的专利证书的一部分。

申请于 1897 年 2 月 17 日提交。1898 年 6 月 15 日更新。序列号 683,524。(没有模型)

To all whom it may concern:

致所有相关人士：

Be it known that I, NIKOLA TESLA, a citizen of the United States, residing at New York, in the county and State of New York, have invented certain new and useful Improvements in Electrical Igniters for Gas-Engines and Analogous Purposes, of which the following is a specification, reference being had to the drawings accompanying and forming a part of the same.

众所周知，我，尼古拉·特斯拉，美国公民，居住在纽约州纽约郡纽约市，在用于燃气发动机的电点火器方面已经发明了某些新的和有用的改进，以下是该发明一个说明书，必须参考随附的图纸，它已形成了该说明书的一部分。

In certain kinds of apparatus it is necessary for the operation of the machine itself or for effecting the object for which it is used to produce an electric spark or any other similar local effect at a given instant of time or at predetermined intervals. For example, in certain gas or explosive engines a flame or spark is necessary for the ignition of an explosive mixture of air and gas under the piston, and the most effective way of igniting the gaseous mixture has been found to be the production in the cylinder at the proper moments of an electric spark. The only practicable device by which this has been accomplished heretofore is an induction-coil comprising a primary and secondary circuit with a buzzer or rapidly-acting automatic circuit-breaker in the primary and a circuit-controller, such as a switch or commutator, located also in the primary or battery circuit and operated by some moving portion of the apparatus to temporarily close such circuit at the proper time, and thereby set in operation the automatic circuit-breaker, which causes between secondary terminals in the cylinder the discharge which is necessary for the proper ignition of the explosive mixture. Instead of thus temporarily closing the primary circuit the automatic circuit-breaker might be permitted to operate continuously, and the secondary, circuit normally broken, might be closed at the proper time to cause the spark to pass at any point. In either case the employment of a quick-acting circuit-breaker is necessary, for unless the induction-coil be of large size and the source of current of considerable power a slow or gradual make and break of the

primary of a simple transformer, such as would ordinarily be effected by a switch or commutator, would not effect a discharge of the character necessary for the proper ignition of the gas.

在某些种类的设备中，为了机器本身的操作或为了实现其目的，需要在给定的时刻或以预定的时间间隔产生电火花或任何其它类似的局部效果。例如，在某些燃气的或爆炸性的发动机中，火焰或火花对于点燃活塞下的空气和气体的爆炸性混合物是必要的，并且已经发现点燃气体混合物的最有效的方式是在适当的时刻在气缸中产生电火花。迄今为止，实现这一点的唯一可行的装置是感应线圈，该感应线圈包括一个初级电路和次级电路，初级电路中具有一个蜂鸣器或快速自动断路器，以及一个电路控制器，例如开关或换向器，该电路控制器也位于初级电路或电池电路中，并由该装置的某个移动部分操作，以在适当的时间暂时闭合该电路，从而使自动断路器工作，这在圆筒中的次级终端之间引起放电，该放电是正确点燃爆炸性混合物所必需的。可以允许自动断路器连续运行，而不是暂时闭合初级电路，而次级电路则通常断开，可以在适当的时间闭合，使火花在任何点通过。在这两种情况下，一个快速断路器的使用是必需的，除非感应线圈是大尺寸和电流源的功率相当大，一个简单的变压器的初级缓慢或逐渐的接通和断开，如通常会受到开关或换向器的影响，不会实现气体的适当点火所需的放电特性。

There is, however, no form of vibrating or quick-acting circuit-breaker of which I am aware that can be depended upon to operate with certainty to produce such a spark or which will continue to operate for any length of time without deterioration, and hence not only in the case of engines of the kind described, but in other forms of apparatus which involve the use of a high-tension induction-coil with a quick-acting circuit-breaker, the operation of the machine is contingent upon the proper operation of a comparatively insignificant but essential part.

然而，据我所知，没有任何一种形式的振动式或快速式断路器，可以可靠地运行来产生这样的火花，或者可以连续运行任何时间而不退化，并且因此不仅在所述类型的发动机的情况下，而且在涉及使用带有快速断路器的高压感应线圈的其他形式的设备中，机器的运行可能取决于相对微不足道但必不可少的部分的正确操作。

The object of my invention is to provide a more certain and satisfactory means for use with and control by such machines or apparatus as I have mentioned for producing sparks or discharges of the desired character, and to this end I employ the following arrangement: Any suitable moving portion of the apparatus is caused to mechanically control the charging of a condenser and its discharge through a circuit in inductive relation to a secondary circuit leading to the terminals between which the discharge is to occur, so that at the desired intervals the condenser may be discharged through its circuit and induce in the other circuit a current of high potential which produces the desired spark or discharge.

我的发明的目的是提供一种更加确定和令人满意的工具，用于与我已经提到的用于产生期望特性的火花或放电的机器或装置一起使用并由它们控制，为此，我采用了以下布置：使该设备的任何合适的移动部分机械地控制一个电容器的充电和该电容器的通过与次级电路成感应关系的电路的放电，该次级电路通向两个终端，在这两个终端之间发生放电，使得以期望的时间间隔，电容器可以通过它的电路放电，并在另一个电路中感应出能产生预期的火花或放电的高电势电流。

One practical means of accomplishing this is to employ any proper form of switch or commutator

operated directly or through suitable intermediate devices by a moving part of the apparatus and which is caused to complete an electric circuit which has been previously broken or interrupted for an appreciable time when the occurrence of the spark or discharge is necessary. The circuit thus closed includes a condenser, which by this operation of the switch is permitted to discharge, through the primary of a transformer, energy which it had previously received during the interruption of said circuit from a battery or discharge of a self-induction coil in series with the battery in the charging-circuit.

实现这一点的一种实用工具是任何适当形式的开关或换向器,它由装置的一个移动部件直接操作或通过适当的中间装置操作,并且当需要发生火花或放电时,使其完成之前已经断开或中断了相当长时间的电路。这样闭合的电路包含一个电容器,通过开关的这种操作,允许电容器通过变压器的一个初级线圈释放能量,该能量是先前在所述电路的中断期间从一个电池或与该电池串联的一个自感线圈的放电来接收的。

The ends of the secondary circuit of the transformer above mentioned are connected with the points or terminals in the machine between which the spark is to pass, and following the short-circuiting of the condenser by the closing of the switch a strong secondary discharge induced by the discharge of the condenser through the primary will occur. It is possible by this means not only to produce a strong discharge of high tension, as in the form of a spark well adapted for the ignition of gas or other purposes for which sparks are employed, but to secure such result by apparatus very much less complicated and expensive than heretofore employed for the purpose and which will be capable of certain and effective operation for an indefinite period of time.

上述提到的变压器的次级电路的末端与机器中的点或终端连接,火花在这些点或终端之间通过,并且在通过闭合开关使电容器短路之后,将会发生由电容器的通过初级的放电所感应产生的强烈的次级放电。利用这种工具,不仅可以产生一个强高压放电,如以火花的形式很好地适用于点燃气体或使用火花的其他目的,而且可以使用比迄今为止用于该目的装置更加简单、更加便宜的装置来确保这种结果,并且该装置将能够在不确定的时间段内进行确定和有效的操作。

I have illustrated the principle of my improvement and the manner in which the same is or may be carried out in the drawing hereto annexed. The invention is shown as used for effecting the operation of the piston of a gas-engine, the figure being a diagram.

我已经在所附的附图中说明了我的改进的原理以及改进中的方式或可以实现的方式。本发明被展示为用于实现燃气发动机的活塞的操作,该图是示意图。

A designates the cylinder of a gas-engine, B the piston, and C the piston-rod. Other parts of the engine are omitted from the illustration as unnecessary to an understanding of the invention.

A 表示一个内燃机的气缸, B 表示活塞, C 表示活塞杆。发动机的其他部分由于对理解本发明没有必要而从示意图中省略。

On the piston-rod C is a commutator or circuit-controller upon which bear the terminals a b of an electric circuit D. This commutator comprises a continuous ring c and a split ring d side by side, so that when the terminals are on the latter the circuit is interrupted, but when on the former it is closed. The

to-and-fro movement of the piston, therefore, operates to alternately make and break the circuit, the position of the commutator being such that the make occurs at the moment desired for the ignition of the explosive charge under the piston.

在活塞杆 C 上是一个换向器或一个电路控制器，其上倚靠着一个电路 D 的终端 a b。该换向器包括并排着的一个连续环 c 和一个开口环 d，从而当终端在后者上时，电路被中断，但是当终端在前者上时，电路被闭合。因此，活塞的往复运动交替地接通和断开电路，换向器的位置使得接通发生在活塞下的爆炸点火所需的时刻。

In the circuit D is a battery or other source of current E and the primary F of a transformer. Across the two conductors of the circuit, between the battery and the primary F, is a condenser G, which is charged by the battery when circuit D is interrupted at the commutator and which discharges through the primary when such circuit is closed.

在电路 D 中的的是一个电池或其他电流源 E 和一个变压器的初级 F。电容器 G 跨接在该电路的两个导体之间，在电池和初级线圈 F 之间，当电路 D 在换向器处中断时，电容器 G 由电池充电，当电路闭合时，电容器 G 通过初级线圈放电。

In order that the condenser may receive a charge of high tension, a self-induction coil H is introduced in the circuit between itself and the battery, which coil stores up the energy of the battery when the circuit D is closed at the commutator and discharges it into the condenser when the circuit is broken.

为了使电容器可以接收高压电荷，在电容器和电池之间的电路中引入一个自感线圈 H，当电路 D 在换向器处闭合时，该线圈储存电池的能量，当电路断开时，该线圈将能量释放到电容器中。

The primary F is combined with a secondary K, the conductors from which lead, respectively, to an insulated terminal L within the cylinder A and to any other conducting body in the vicinity of such point as the cylinder itself. In consequence of this arrangement, when the piston reaches the proper point the circuit D is closed, the energy of the condenser is discharged through the primary with a sudden rush, and a strong and effective spark or flash is produced between the point L and the cylinder or piston which ignites the charge of explosive gas.

初级线圈 F 与一个次级线圈 K 相结合，从次级线圈 K 引出的导线分别通向圆筒 A 内的被绝缘的终端 L 和圆筒本身附近的任何其它导体。由于这种布置，当活塞到达适当的点时，电路 D 闭合，电容器的能量通过初级电路突然释放，并且在点 L 和点燃爆炸性气体的气缸或活塞之间产生强烈有效的火花或闪光。

It will be understood from the preceding description that I do not limit myself to the specific construction or arrangement of the devices employed in carrying out my improvement and that these may be varied within wide limits.

从前面的描述中可以理解，我并不将自己局限于用于实现我的改进的装置的具体结构或布置，并且这些可以在很宽广的范围内变化。

What I claim is—

我主张的是—

1. In an apparatus which depends for its operation or effect upon the production of a sudden electric discharge at a given instant, or at predetermined intervals of time, the combination with a moving part of said apparatus of a switch or commutator, a condenser, a charging-circuit for the same, a primary circuit through which the condenser discharges, and a secondary circuit in inductive relation to the said primary circuit and connected with the terminals at the point in the apparatus where the discharge is required, the switch or commutator being operated by the said moving part to effect the discharge of the condenser at the proper intervals, as set forth.

1、在一种设备中，其操作或效果取决于在一个给定时刻或在预定的时间间歇内产生的突然放电，还存在着一个组合，它包括一个开关或者换向器的所述装置的一个移动部件；一个电容器；为该电容器充电的一个电路；该电容器的放电所通过的一个初级电路；与所述初级电路成感应关系的次级电路，该电路与设备中需要放电的点的终端相连；所述开关或者换向器由所述移动部件操作，以适当的时间间隔来实现电容器放电，如上所述。

2. In an apparatus which depends for its operation or effect upon the production of a sudden electric discharge at a given instant, or at predetermined intervals of time, the combination with a moving part of said apparatus of a circuit and a circuit-controller adapted to close said circuit at the time when the occurrence of said discharge is desired, a source of current in said circuit, a condenser adapted to be charged by said source while the circuit is interrupted, and a transformer through the primary of which the condenser discharges when the circuit is closed, the secondary of the transformer being connected with the terminals at the point in the apparatus where the discharge is required, as set forth.

2、在一种设备中，其操作或效果取决于在一个给定时刻或以预定的时间间隔产生的突然放电，还存在着一个组合，它包括一个电路的所述装置的一个移动部件；一个电路控制器，适于在期望发生所述放电时闭合所述电路；在所述电路中的一个电流源；一个电容器，适于在电路中断时由所述电源充电；一个变压器，当电路闭合时，电容器通过该变压器的初级放电；变压器的次级，它与设备中需要放电的点的终端相连，如上所述。

3. In an apparatus which depends for its operation or effect upon the production of an electric discharge, at a given instant, or at predetermined intervals of time, the combination with a moving part of said apparatus of a circuit and a circuit-controller adapted to close said circuit at the time when the occurrence of the spark is desired, a source of current in said circuit, a self-induction coil which stores the energy of the source while the circuit is closed, a condenser into which said coil discharges when the circuit is broken, and a transformer through the primary of which the condenser discharges, the secondary of said transformer being connected with separated terminals at the point where the discharge is required, as set forth.

3、在一种设备中，其操作或效果取决于在一个给定时刻或以预定的时间间隔产生的突然放电，还存在着一个组合，它包括一个电路的所述装置的一个移动部件；一个电路控制器，适于在期望发生所述放电时闭合所述电路；在所述电路中的一个电流源；在电路闭合时存储电源能量的自感线圈；一个电容器，当电路断开时，所述线圈向该电容器放电；以及一个变

压器，电容器通过该变压器的初级放电，所述变压器的次级线圈在需要放电的点与分离的终端连接，如上所述。

4. In a gas or explosive engine of the kind described, the combination with a moving part of said engine, of a circuit-closer or switch controlling the charging and discharging of a condenser, separated terminals in the cylinder or explosive-chamber, and a transformer through the primary of which the condenser discharges, the secondary being connected with the terminals in the cylinder, as set forth.

4、在所述类型的一个燃气的或爆炸式的发动机中，存在一个组合，它包括控制着一个电容器的充电和放电的一个开关闭合器或者电路闭合器；所述发动机的一个移动部件；气缸中或爆炸室中的分离的终端；一个变压器，电容器通过该变压器的初级线圈放电，变压器的次级连接到气缸中的终端上，如上所述。

NIKOLA TESLA.

尼古拉·特斯拉

Witnesses:

M. LAWSON DYER,

EDWIN B. HOPKINSON.

见证人:

M.劳森·戴尔、埃德温·霍普金森。

No. 609,250

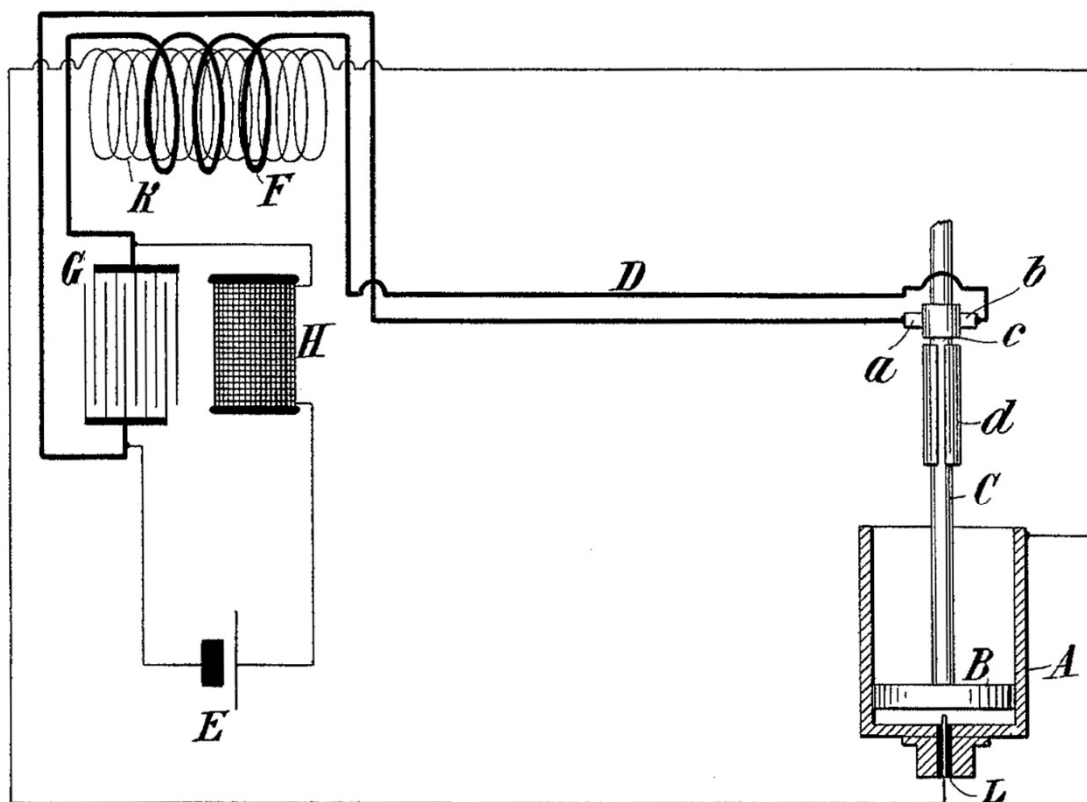
Patented Aug. 16, 1898.

N. TESLA.

ELECTRICAL IGNITER FOR GAS ENGINES.

(Application filed Feb. 17, 1897. Renewed June 15, 1898.)

(No Model.)



Witnesses:

M. Lamon Gyr.

Edwin B. Hopkinson.

Nikola Tesla, Inventor

by Kerr, Curtis & Rogers, Attys.

ELECTRIC-CIRCUIT CONTROLLER.

电路控制器

NIKOLA TESLA, OF NEW YORK, N. Y.

纽约州纽约市的尼古拉·特斯拉

SPECIFICATION forming part of Letters Patent No. 609,251, dated August 16, 1898.

Application filed June 8, 1897. Renewed June 15, 1898. Serial No. 683,525. (No model.)

该说明书形成了颁发于 1898 年 8 月 16 日编号为 609,251 的专利证书的一部分。

该申请于 1897 年 6 月 8 日提交。更新于 1898 年 6 月 15 日。序列号为 683,525。(没有模型)

To all whom it may concern:

致所有相关人士:

Be it known that I, NIKOLA TESLA, a citizen of the United States, residing at New York, in the county and State of New York, have invented certain new and useful Improvements in Electric-Circuit Controllers, of which the following is a specification, reference being had to the drawings accompanying and forming a part of the same.

众所周知，我，尼古拉·特斯拉，一名美国公民，居住在纽约州纽约郡纽约市，在电路控制器方面已经发明了某些新的和有用的改进，以下是该发明一个说明书，必须参考随附的图纸，它已形成了该说明书的一部分。

In previous patents granted to me I have shown and described methods and apparatus for the conversion and utilization of electrical current of very high frequency based upon the principle of charging a condenser or a circuit possessing capacity and discharging the same generally through the primary of a transformer, the secondary of which constituted the source of working current and under such conditions as to yield a vibrating or rapidly-intermittent current.

在授予我的以前的专利中，我已经展示和描述了用于转换和利用甚高频的电流的方法和装置，其原理是对电容器或具有电容量的电路充电，并且通常通过一个变压器的初级对其进行放电，变压器的次级构成工作电流源，并且在这样的条件下产生振动或快速间歇的电流。

In some of the forms of apparatus which I have heretofore devised for carrying out this invention I have employed a mechanism for making and breaking an electric circuit or branch thereof for the purpose of charging and discharging the condenser, and my present application is based upon a novel and improved form of device for this purpose, which may be generally styled a “circuit-controller.”

在我迄今为止为实现本发明而设计的一些形式的装置中，我采用了一种用于接通和断开电路或其分支的机械装置，以便对电容器进行充电和放电，并且我的本申请基于一种用于此目的的新颖和改进后的装置形式，它通常可以被称为“电路控制器”

In order that the full advantages of my system may be realized and the best practical results secured, the said circuit-controller should be capable of fulfilling certain requirements, the most important among which is the capability of effecting an extremely-rapid interruption and completion of the circuit. It is also of importance that such makes and breaks, and more especially the former, should be positive and abrupt, and from considerations of economy and practicability it is essential that the apparatus should be cheaply constructed, not liable to derangement, and capable of prolonged use without attention or adjustment. With the object of attaining these results, which have never heretofore been fully attained in any form of mechanical circuit-controller of which I am aware, I devised and developed the circuit-controller which forms the subject of my present application and which may in general terms be described as follows:

为了实现我的系统的全部优点和确保最佳的实际结果,所述电路控制器应该能够满足某些要求,其中最重要的是实现电路的极快的中断和复原的能力。同样重要的是,这种接通和断开,尤其是前者,应该是主动的和突然的,从经济性和实用性的角度考虑,从经济性和实用性的角度考虑来看,该设备应该低廉地构建,这是必不可少的,这样才不容易发生故障,并且能够在不加注意或调整的情况下长期使用。为了获得这些迄今为止在我所知道的任何形式的机械电路控制器中从未完全获得的结果,我设计并开发了电路控制器,它构成了我目前申请的主题,并且可以概括地描述如下:

The device in its typical embodiment comprises as essential elements two terminals—one with peripheral contacts alternating with insulating-spaces, such as is exemplified in a stelliform disk and which is capable of rotation, and the other a rotatable receptacle containing a fluid in which more or less of the first-named terminal is immersed.

该装置在其典型实施例中包括作为基本组件的两个终端——一个终端具有与绝缘空间交替的外围触点,例如在星形盘中,并且能够旋转,另一个终端是容纳流体的可旋转容器,第一个终端或多或少浸没在该容器中。

In the preferred construction of the apparatus the receptacle contains both a conducting and non-conducting fluid, the former being the heavier, and I maintain the terminals in such relations that the electrical connection between them is made and broken by the successive immersion of the contact-points into and their withdrawal from the conducting through the non-conducting fluid. These relations are best maintained by such construction of the receptacle that the distribution of the two fluids necessary for the proper operation of the device may be preserved by centrifugal action and the rotation of the other terminal effected by the movement of the fluid or fluids relatively thereto.

在该设备的优选结构中,容器容纳一种导电流体和一种非导电流体,前一种流体较重,并且我将终端保持在这样的关系中,即它们之间的电连接是通过接触尖端连续浸入导电流体和从导电流体中抽出以完成接通和断开的。通过容器的这种结构可以最好地保持这些关系,使得装置正常操作所需的两种流体的分配可以通过离心作用和另一个终端的旋转来保持,该另一个终端的旋转通过一种或多种流体相对于该终端的运动来实现。

To secure the conditions necessary for the accomplishment of the objects of the invention, various mechanical expedients may be resorted to; but the best and most practicable device for the purpose of which I am aware is a hollow wheel or drum mounted so as to be rotated at any desired speed and

containing a conducting fluid, such as mercury or an electrolyte, which by the rotation of the drum is thrown by centrifugal force outward to the inner periphery of the same, and a sufficient quantity of a lighter non-conducting or poorly-conductive fluid, such as water or oil, which by the centrifugal action is maintained on the surface of the heavier conducting fluid and tends to prevent the occurrence of arcs between the contact-points and the conducting fluid.

为了确保实现本发明的目的所必需的条件,可以采用各种机械性的权宜之计;但是就我所知的目的而言,最好的且最可行的装置是安装成以任何所需的速度旋转的一个空心轮或空心鼓,它容纳导电流体,例如水银或电解液,通过鼓的旋转,该导电流体通过离心力向外被甩到鼓的内周,以及足够量的较轻的不导电或导电性差的流体,例如水或油,它通过离心作用保持在较重的导电流体的表面上,并且倾向于防止在接触尖端和导电流体之间出现电弧。

A central opening is formed in one side of the drum, through which enters an arm carrying a disk with peripheral projections or vanes which when the drum is rotated project to a sufficient extent toward or into the conducting fluid to effect the makes and breaks of the circuit.

在鼓的一侧形成一个中心开口,携带一个盘的一个臂进入该开口中,该盘的周边具有突起或叶片,当鼓旋转时,该突起或叶片朝向或进入导电流体一个足以实现电路的接通和断开的程度。

The motion of the fluid within the drum causes the disk to rotate and its projections or vanes to make and break the circuit with a rapidity which may be very great. In fact, when the drum is rotated at a high rate of speed the fluid conductor may become in its effect similar to a solid body, upon which the conducting-disk rolls, so that the conducting fluid might be dispensed with, although I find it preferable to use it.

鼓内流体的运动导致盘旋转,盘的突起或叶片以非常快的速度接通和断开电路。事实上,当鼓以高速旋转时,流体导体在效果上可能变得类似于固体,导电盘在该流体上滚动,因此导电流体可能被省去,尽管我发现最好使用它。

In order to insure the proper immersion of the projections into the fluid to compensate for wear and at the same time to secure a yielding pressure between the fluid and the disk, it is desirable to employ for the disk some form of spring connection or support which will exert a force tending to force it in contact with the fluid.

为了确保突起适当地浸入流体中以补偿磨损,同时确保流体和盘之间的弯曲压力,需要对盘采用某种形式的弹簧连接或支撑,后者将施加倾向于迫使盘与流体接触的力。

I have also devised certain details of construction which add to the efficiency and practicability of the apparatus which will be more conveniently described by reference to the accompanying drawings.

我还设计了增加该装置的效率和实用性的某些结构细节,这将通过参考附图更方便地描述。

Figure 1 is a side elevation of a complete apparatus for producing currents of high frequency and to which my present invention is applied. Fig. 2 is a central vertical section of the improved circuit-

controller of Fig. 1; Fig. 3, an end view of the same; Fig. 4, a modified form of the circuit-controller, showing it in connection with the remaining parts of the apparatus illustrated diagrammatically; and Fig. 5, a side view of the same with the receptacle in section.

图 1 是用于产生高频电流的一个完整装置的侧视图，本发明应用于该设备。图 2 是图 1 的改进后的电路控制器的中心垂直剖面图；图 3 是其端视图；图 4 是电路控制器的修改形式，展示了它与示意性展示的设备其余部分的连接；以及图 5 是该容器的截面侧视图。

As the apparatus as a whole is now well known, a brief description of the same will suffice for an understanding of its character.

由于该装置作为一个整体现在是众所周知的，对其的简要描述将足以理解其特征。

The various parts or devices are preferably mounted on a base B, which contains the condenser, and comprise a transformer A with primary and secondary coils, one or more self-induction coils C, a small electromagnetic motor D, and the circuit-controller, which is driven by the motor. The circuit connections will be described in connection with Fig. 5.

各种部件或装置最好安装在容纳电容器的一个基座 B 上，该基座包括具有初级线圈和次级线圈的变压器 A、一个或多个自感应线圈 C、一个小型电磁电动机 D 和由该电动机驱动的电
路控制器。将结合图 5 描述电路连接。

In general plan of construction and arrangement the apparatus is essentially the same as that described and shown in a patent granted to me September 22, 1896, No. 568,176.

在结构和布置的总平面图中，该装置基本上与 1896 年 9 月 22 日授予本人的第 568,176 号专利中描述的和展示
的相同。

The shaft of the motor D extends through a stationary disk E, and to its end is keyed a hollow wheel or drum F, which rotates with it. Two standards G are secured to the disk E and connected by a cross-bar H, from which extends an arm K into the interior of the drum F through a central opening in its side.

电动机 D 的轴延伸穿过一个静态盘 E，并且一个空心轮或空心鼓 F 被榫接到该轴的端部，并与该轴一起旋转。两个立柱 G 被固定在盘 E 上，并由横杆 H 连接，臂 K 从横杆 H 通过鼓 F 侧面的中心开口伸入它的内部。

To the end of the arm K is secured an arm L, carrying at its free end a disk M with peripheral teeth or projections N, as shown in Fig. 3. The disk is mounted on any suitable bearings in the arm L, so as to be capable of free rotation.

如图 3 所示，臂 L 被固定在臂 K 的端部，在臂 L 的自由端携带一个具有外周齿或外周突起 N 的圆盘 M。该盘被安装在臂 L 中的任何合适的轴承上，以便能够自由旋转。

It is desirable that the disk should admit of adjustment with respect to the inner peripheral surface of

the drum, and for this purpose I secure the arm K to a rod O, which passes through supports in the cross-bar H and is adjustable therein by means of threaded nuts P.

理想的是,应该允许盘相对于鼓的内周表面进行调节,为此目的,我将臂 K 固定到杆 O 上,杆 O 穿过横杆 H 中的支撑件,并可在横杆 H 中通过螺母 P 进行调节。

The interior of the drum F is formed by preference in substantially the manner shown in Fig. 2—that is to say, it is tapered or contracted toward the periphery so as to form a narrow trough in which the fluid is confined when the drum is rotated.

鼓 F 的内部最好基本上以图 2 所示的方式形成,也就是说,其朝向外周逐渐锥化或收缩,从而形成狭窄的槽,当鼓旋转时,流体被限制在该槽中。

R designates the conducting fluid, and S the lighter non-conducting fluid, which are used in the drum. If the proper quantities and proportions of these fluids be introduced into the drum and the latter set in rapid rotation, the two fluids will distribute themselves under the action of centrifugal force around the drum in the manner indicated in Fig. 2. The arm K is adjusted so that the teeth or projections on the disk M will just enter the conducting fluid, and by the action of either or both the disk will be rapidly rotated. Its teeth are so arranged that no two are simultaneously in contact with the conducting fluid, but come into the same successively. If, therefore, one part of the circuit be connected to the drum, as by a contact strip or brush T, and the other part to the disk M, or to any part, as the standards G, which are insulated from the frame of the apparatus and in metallic connection with the disk M, the circuit will be made and broken with a rapidity which may obviously be made enormously high. The presence of the non-conducting fluid on the surface of the other operates to prevent the occurrence of sparks as the teeth N leave the latter and also to prevent the current from leaping across the space between the teeth and the conductor as the two approach.

R 表示导电流体, S 表示较轻的非导电流体,用于鼓中。如果将适当数量和比例的这些流体导入鼓中,并使鼓快速旋转,这两种流体将在离心力的作用下以图 2 所示的方式围绕滚筒分布。调节臂 K,使得盘 M 上的齿或突起刚好进入导电流体,并且通过其中一个或两个齿的作用,盘将快速旋转。它的齿如此排列,以至于没有两个同时与导电流体接触,而是相继进入导电流体。因此,如果电路的一部分通过一个接触条或电刷 T 连接到鼓上,而另一部分连接到盘 M 或任何部分上,如与设备的框架绝缘并与盘 M 金属连接的立柱 G 上,则电路将以明显非常高的速度接通和断开。另一个表面上的不导电流体的存在防止了当齿 N 离开后者时产生火花,并且还防止了当齿和导体接近时电流跨越齿和导体之间的空间。

In illustration of the modifications of which the improvement is susceptible I now refer to Figs. 4 and 5, in which also certain novel and useful details of construction applicable generally to the invention are shown.

为了说明易于改进的修改,现在参考图 4 和图 5,这些图也展示了通常适用于本发明的某些新颖和有用的结构细节。

In the modification shown in Figs. 4 and 5 two rigid arms L and L', each carrying a disk M, are shown, and this number may be increased, if so desired. The rotating disks in this case are mounted on spindles

at right angles to the axis of rotation of the drum F, and the contact points or projections are formed as vanes, with faces inclined to the plane of rotation, so as to be rotated by the movement of the fluid in the manner of turbine wheels.

在图 4 和图 5 所示的改型中，展示了两个刚性臂 L 和 L'，每个臂携带一个盘 M，如果需要，这个数目可以增加。在这种情况下，旋转盘被安装在与鼓 F 的旋转轴线成直角的轴上，并且接触点或突起形成为叶片，其表面倾斜于旋转平面，从而以涡轮的方式通过流体的运动而旋转。

In order to provide a means for automatically adjusting the disks to compensate for any wear and keep the ends of the vanes or points properly immersed in the fluids, each disk-carrying arm is impelled by a spring or weight in the direction of the periphery of the drum. A convenient way to accomplish this is to form racks on the arms L L' and to provide a pinion b in engagement therewith. From the shaft of the pinion extends an arm c, the end of which is connected to an adjustable stop d by a spiral spring e, the tendency of which is to turn the pinion and force both arms L and L' toward the periphery of the drum.

为了提供一种能自动调节盘的装置，以补偿任何磨损并保持叶片或尖端的端部适当地浸入流体中，每个由盘携带的臂被弹簧或重物在鼓的外周方向上驱使。实现这一点的便利方式是在臂 L L' 上形成齿条，并提供与其啮合的小齿轮 b。从小齿轮的轴延伸出一个臂 c，该臂的端部通过一个螺旋弹簧 e 连接到一个可调节的止动件 d 上，螺旋弹簧 e 的倾向是转动小齿轮并迫使臂 L 和 L' 向着鼓的外周运动。

In some applications of the invention it is practicable to prevent the occurrence of arcs still more effectively or even entirely by using in addition to the non-conducting fluid a somewhat heavier fluid W, which is a comparatively poor conductor and which takes up a position between the conducting and non-conducting fluids.

在本发明的一些应用中，通过除了使用非导电流体之外还使用稍微重一些的流体 W 来更有效地或者甚至完全地防止电弧的发生是可行的，该流体 W 是相对不良的导体，并且占据了导电和非导电流体之间的位置。

When two or more disks or equivalent devices are used, they may be connected either in series or multiple. In the present illustration they are shown as in series, and as the arms L and L' are insulated from each other and each connected with a terminal of the source of current the circuit is completed only when a vane of each disk is immersed in the conducting fluid and interrupted at all other times.

当使用两个或更多盘或等效设备时，它们可以串联或并联。在本图示中，它们被示为串联，并且由于臂 L 和 L' 彼此绝缘，并且每一个都与电流源的终端连接，所以只有当每个盘的叶片浸入导电流体中时，电路才是完整的，并且在所有其他时间电路都是中断的。

The diagram of circuit connections will serve to illustrate the purpose and mode of operation of the device. Let f f be the conductors from a source of current, each including a self-induction coil C C' and connected with the arms L and L' and with two conductors B' B", respectively. Then during the periods when the circuit is completed between the two arms L L' the coils C C' store energy, which on the

interruption of said circuit rushes into and charges the condenser. These latter during the periods when the circuit is closed between arms L and L' discharge through the primary A' and induce by such discharge currents in the secondary A", which are utilized for any purpose for which they may be suited, as in operating vacuum-tubes X or suitable lamps Y.

电路连接图将用于说明设备的用途和操作模式。让 f f 是源自电流源的导体，每个导体包括一个自感线圈 C C'，分别与臂 L 和 L' 以及两个导体 B' B" 连接。然后，在两个臂 L L' 之间的电路闭合期间，线圈 C C' 存储能量，在所述电路中断时，该能量流入电容器并对其充电。在臂 L 和 L' 之间的电路闭合期间，后者通过初级 A' 放电，并用这种放电在次级 A" 感应出电流，这种感应电流可用于它们可以适合的任何目的，如操作真空管 X 或合适的灯 Y。

It will be understood that the rotating drum may be mounted in a horizontal or other plane and from the nature and objects of the results which are attained by the particular apparatus described the construction of this apparatus may be very greatly varied without departure from my invention.

可以理解的是，转鼓可以安装在水平面或其他平面上，并且从所述特定装置获得的结果的性质和目的来看，该装置的结构可以有很大的变化，而不背离我的发明。

Without therefore limiting myself to the details of construction and arrangement shown herein in illustration of the manner in which my invention is or may be carried out, what I claim is—

因此，在不将我自己限制于在此展示的结构和布置的细节的情况下，为了说明我的发明被执行或可能被执行的方式，我主张的是—

1. A circuit-controller comprising, in combination, a receptacle containing a fluid, means for rotating the receptacle, and a terminal supported independently of the receptacle and adapted to make and break electric connection with the receptacle through the fluid, as set forth.

1、一种电路控制器，它包括：容纳一种流体的一个容器；用于旋转容器的装置；以及独立于容器被支撑的并适于通过流体与容器建立和断开电连接的一个终端，如前所述。

2. A circuit-controller comprising in combination a receptacle containing a conducting fluid and a non-conducting fluid, means for rotating the receptacle and a terminal adapted for make and break electrical connection with the conducting fluid within or under the non-conducting fluid, as set forth.

2、一种电路控制器，它包括：容纳导电流体和非导电流体的一个容器；用于旋转容器的装置和适于建立和断开与非导电流体内部或下方的导电流体的电连接的终端，如前所述。

3. A circuit-controller comprising in combination a terminal capable of rotation and formed or provided with peripheral contacts, a receptacle comprising the opposite terminal and containing a fluid into which the said contacts extend, and means for rotating the receptacle, as set forth.

3、一种电路控制器，它包括：能够旋转并形成或配有外围触点的一个终端；包括另一终端并容纳一种流体的容器，所述触点延伸到所述流体中；以及用于旋转容器的装置，如前所述。

4. A circuit-controller, comprising, in combination, a terminal capable of rotation and formed or provided with peripheral projections, a receptacle containing a fluid conductor into which the points or projections of the said conductor extend, and means for rotating the said receptacle, as set forth.

4、一种电路控制器，它包括：能够旋转并形成或配有外围突起的一个终端；容纳流体导体的一种容器和用于旋转所述容器的装置；所述导体的尖端或突起延伸到所述容器中，如前所述。

5. A circuit-controller comprising, in combination, a terminal capable of rotation and formed or provided with peripheral projections, a centrifugal drum or wheel containing a fluid conductor into which the points or projections of the said conductor extend, and means for rotating the said drum, as set forth.

5、一种电路控制器，它包括：能够旋转并形成或配有外围突起的一个终端；容纳一种流体导体的一个离心鼓或轮；所述导体的尖端或突起延伸到所述流体导体中；以及用于旋转所述鼓的装置，如前所述。

6. A circuit-controller comprising, in combination, a terminal capable of rotation and formed or provided with peripheral projections, a centrifugal drum or wheel containing a fluid conductor into which the points of the said terminal extend, and means for adjusting the latter with relation to the surface of the fluid, as set forth.

6、一种电路控制器，它包括：能够旋转并形成或配有外围突起的一个终端；容纳一种流体导体的一个离心鼓或轮；所述终端尖端延伸进入到所述流体导体中；以及用于调节终端尖端相对于流体表面的装置，如前所述。

7. A circuit-controller comprising, in combination, a terminal having peripheral projections and capable of rotation, a centrifugal drum or receptacle containing a conducting and a lighter non-conducting fluid, the said terminal being arranged so that its points or projections extend through the non-conducting into the conducting fluid, when the fluids are distributed in the drum under the action of centrifugal force, as set forth.

7、一种电路控制器，它包括：具有外围突起并能够旋转的一个终端；容纳一种导电的和一种较轻的不导电的流体的离心鼓或容器；所述终端被布置成使得当流体在离心力的作用下在鼓中分布时；其尖端或突起穿过不导电流体延伸到导电流体中，如前所述。

8. The combination with a hollow centrifugal drum or wheel containing a conducting fluid, a motor for rotating the same, a support extending through an opening into the drum, and a rotatable terminal having peripheral projections, mounted on said support in position in which its projections extend into the fluid when displaced by centrifugal action, as set forth.

8、存在一个组合，包括：容纳一种导电流体的中空离心鼓或轮；用于旋转该鼓的电动机；穿过一个开口延伸到鼓中的一个支撑件；以及具有外围突起的一个可旋转终端，该终端被安装在所述支撑件上的适当位置，在该位置，当通过离心作用移动时，其突起延伸到流体中，如前所述。

9. The combination with a receptacle containing a fluid and means for rotating the same, a terminal with peripheral projections capable of rotation, and a spring connection or support for said terminal tending to force it toward the periphery of the receptacle, as set forth.

9、存在一个组合，包括：容纳流体的容器和用于旋转该容器的装置；能够旋转的具有外围突起的一个终端；以及用于所述终端的一个弹簧连接或支撑，倾向于驱使该终端朝向容器外围运动，如前所述。

10. The combination with a hollow centrifugal drum or wheel containing a conducting fluid and a lighter non-conducting fluid, means for rotating the said drum, a support extending through an opening into the drum, and a rotatable terminal having peripheral projections, mounted on said support in position in which the projections extend through the non-conducting into the conducting fluid when the fluids are displaced by centrifugal action, as set forth.

10、存在一个组合，包括：容纳一种导电流体和一种较轻的不导电流体的中空离心鼓或轮、用于旋转所述鼓的装置；穿过开口延伸到鼓中的支撑件；以及具有外围突起的可旋转的终端，该终端被安装在所述支撑件上的适当位置，在该位置，当流体通过离心作用移动时，突起延伸穿过不导电流体进入导电流体，如前所述。

11. The combination with a centrifugal drum containing a conducting and a non-conducting fluid, means for rotating the drum, a terminal capable of rotation and having peripheral projections, mounted within the drum on a stationary support, and a spring or its equivalent acting on the said terminal and tending to force its projections toward the inner periphery of said drum as set forth.

11、存在一个组合，包括：容纳一种导电和一种不导电流体的离心鼓；用于旋转鼓的装置；能够旋转并具有外围突起的一个终端，所述终端被安装在鼓内的一个静止支撑件上、以及一个弹簧或其等同物，它们作用在所述终端上并倾向于驱使终端上的突起朝向所述鼓的内周运动，如前所述。

12. The combination with a receptacle containing a conducting fluid, a lighter fluid low conductivity and a non-conducting fluid lighter than the others, and means for rotating the receptacle, of a terminal adapted to make and break the circuit by movements between the conducting and non-conducting fluid through the intermediate fluid of low conductivity, as set forth.

12、存在一个组合，包括：容纳一种导电流体；一种低电导率的较轻流体和比其它流体都轻的非导电流体的容器；以及用于旋转该容器的装置；一种终端，适于利用在导电和非导电流体之间的穿过低电导率的中间流体的运动来接通和断开电路，如前所述。

NIKOLA TESLA.
尼古拉·特斯拉

Witnesses:

M. LAWSON DYER,
PARKER W. PAGE.

证人: M.劳森·戴尔、帕克·W·佩奇。

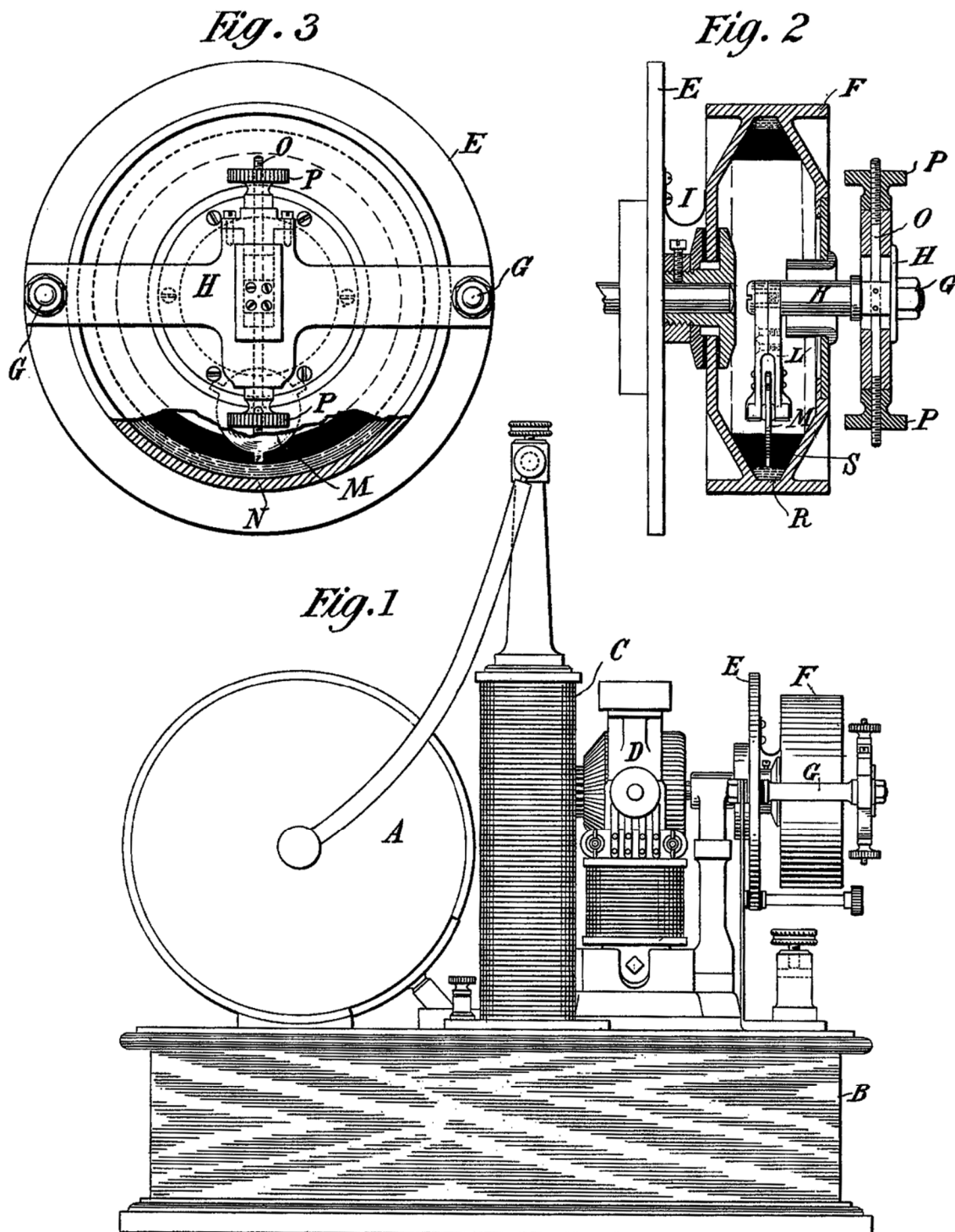
N. TESLA.

ELECTRIC CIRCUIT CONTROLLER.

(Application filed June 3, 1897. Renewed June 15, 1898.)

(No Model.)

2 Sheets—Sheet 1.



Witnesses:
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N. TESLA.

ELECTRIC CIRCUIT CONTROLLER.

(Application filed June 3, 1897. Renewed June 15, 1898.)

(No Model.)

2 Sheets—Sheet 2.

Fig. 4

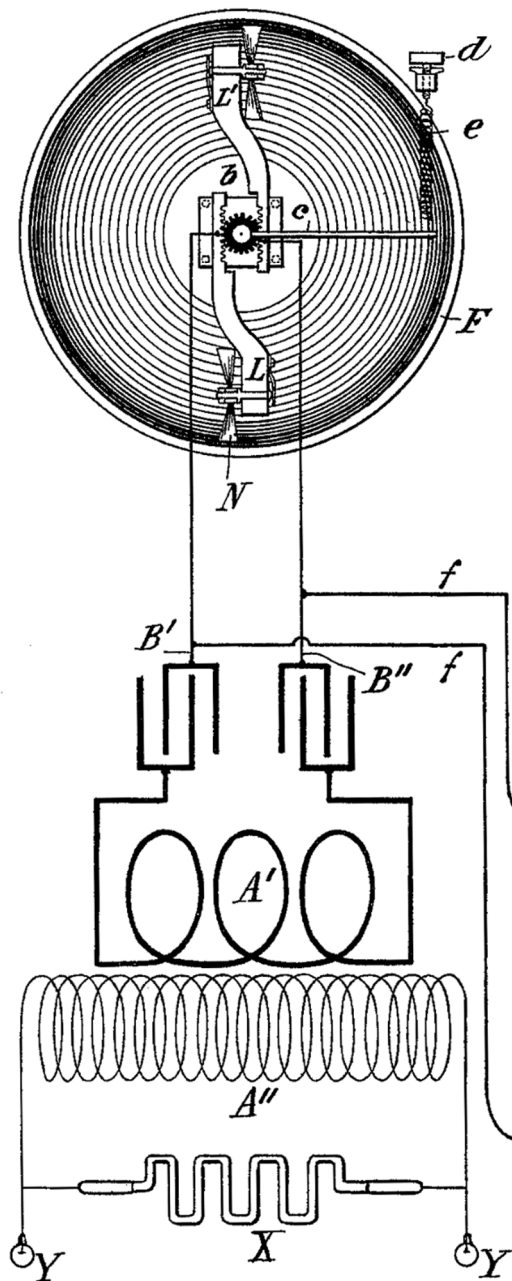
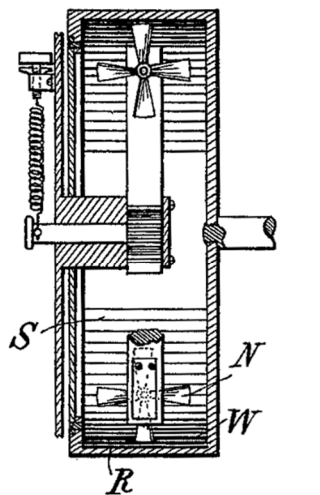


Fig. 5



WITNESSES

Edwin B. Hopkinson,
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INVENTOR

Nikola Tesla

BY

Kerr, Curtis & Page
ATTORNEYS.

ELECTRICAL-CIRCUIT CONTROLLER.

电路控制器

NIKOLA TESLA, OF NEW YORK, N. Y.

纽约州纽约市的尼古拉·特斯拉

SPECIFICATION forming part of Letters Patent No. 611,719, dated October 4, 1898.

Application filed December 10, 1897. Serial No. 661,403. (No model.)

该说明书形成了颁发于 1898 年 10 月 4 日编号为 611,719 的专利证书的一部分。

该申请于 1897 年 12 月 10 日提交。序列号为 661,403。(没有模型)

To all whom it may concern:

致所有相关人士:

Be it known that I, NIKOLA TESLA, residing at New York, in the county and State of New York, have invented certain new and useful Improvements in Electrical-Circuit Controllers, of which the following is a specification, reference being had to the drawings accompanying and forming a part of the same.

众所周知,我,尼古拉·特斯拉,一名美国公民,居住在纽约州纽约郡纽约市,在电路控制器方面已经发明了某些新的和有用的改进,以下是该发明一个说明书,必须参考随附的图纸,它已形成了该说明书的一部分。

In order to secure a more efficient working of circuit-controllers, particularly in their use in connection with my system of electrical-energy conversion by means of condenser discharges, I have devised certain novel forms of such appliances, comprising as essential elements a body of conducting fluid constituting one of the terminals, a conductor or series of conductors forming the other terminal, and means for bringing the two into rapidly-intermittent contact with each other. These devices possess many desirable qualities, particularly that of being eminently adapted for making and breaking at a very rapid rate an electric circuit and thus reducing to a minimum the time of passage of the current through an arc or path of high resistance and diminishing thereby the losses incident to the closure and interruption of the circuit. Continued experimentation with these appliances has led me to make further important improvements by causing the make-and-brake to be effected in an inert medium of very high insulating power.

为了确保电路控制器更有效地工作,特别是在与我的通过电容器放电进行电能转换的系统结合使用时,我已经设计了这种设备的某些新形式,包括作为基本组件的构成一个终端的导电流体、形成另一个终端的导体或一连串导体、以及用于使这两个终端彼此快速间歇地接触的装置。这些装置具有许多理想的特性,特别是非常适合于以非常快的速度接通和断开电路,从而将电流通过高电阻的一个电弧或路径的时间减少到最小,从而减少了电路闭合和断开时的损耗。对这些设备的持续实验使我做出了进一步的重要改进,即在绝缘能力非常高的惰性

介质中实现通断。

It is a fact, which was fully demonstrated by Poggendorff and utilized by him to improve the operation of induction-coils, that when the contact-points of a circuit-breaker are enclosed in a vessel and the latter exhausted to a high degree the interruption of the current is rendered more sudden, as if a condenser were connected around the break. Furthermore, my own investigations have shown that under such conditions the closure also is more sudden, and this to even a greater degree than the break, which result I attribute to the high insulating quality of the vacuous space, in consequence of which the electrodes may be brought in very close proximity before an arc can be formed between them. Obviously these facts may be utilized in connection with my novel circuit-controllers; but inasmuch as only a very moderate improvement is secured in this manner and as the high vacuum required is quickly destroyed and cannot be maintained, unless by a continuous process of rarefaction and other inconvenient measures, I have found it desirable to employ more effective and practical means to increase the efficiency of the devices in question. The measures I have adopted for this purpose have resulted from my recognition of certain ideal qualifications of the medium wherein to effect a make-and-break. These may be summed up as follows: First, the medium by which the contact-points are surrounded should have as high an insulating quality as possible, so that the terminals may be approached to an extremely short distance before the current leaps across the intervening space; second, the closing up or repair of the injured dielectric, or, in other words, the restoration of the insulating power, should be instantaneous in order to reduce to a minimum the time during which the waste principally occurs; third, the medium should be chemically inert, so as to diminish as much as possible the deterioration of the electrodes and to prevent chemical processes which might result in the development of heat or, in general, in loss of energy; fourth, the giving way of the medium under the application of electrical pressure should not be of a yielding nature, but should be very sudden and in the nature of a crack, similar to that of a solid, such as a piece of glass when squeezed in a vise, and, fifth, most important, the medium ought to be such that the arc when formed is restricted to the smallest possible linear dimensions and is not allowed to spread or expand. As a step in the direction of these theoretical requirements I have employed in some of my circuit-controlling devices a fluid of high insulating qualities, such as liquid hydrocarbon, and caused the same to be forced, preferably with great speed, between the approaching and receding contact-points of the circuit-controller. By the use of such liquid insulator a very marked advantage was secured; but while some of the above requirements are attained in this manner certain defects still exist, notably that due to the fact that the insulating liquid, in common with a vacuous space, though in a less degree, permits the arc to expand in length and thickness, and thus pass through all degrees of resistance and causing a more or less considerable waste of energy. To overcome this defect and to still more nearly attain the theoretical conditions required for most efficient working of the circuit-controlling devices, I have been finally led to use a fluid insulating medium subjected to great pressure.

波根多夫充分证明并利用这一事实来改进感应线圈的运行,当断路器的接触点被封闭在一个容器中,后者被抽真空到一个很高的程度,电流的中断呈现得更突然,好像在断点周围连接了一个电容器。此外,我自己的研究表明,在这种条件下闭合也更突然,这甚至比中断更加突然,这一结果我归因于真空空间的高绝缘质量,结果是电极可以在它们之间形成电弧之前就能靠得很近。显然,这些事实可以与我的新型电路控制器一起使用;但是由于以这种方式只能获得一个非常适度的改进,并且除非通过持续的抽真空过程和其他不方便的措施,否则所需的高真空很快被破坏并且不能保持,所以我发现希望采用更有效和更实用的方法来提高

所述装置的效率。我为这个目的采取的措施来自于我对介质的某些能实现通断的理想资格的认识。这些可以总结如下:第一、接触点周围的介质应具有尽可能高的绝缘质量,以便在电流跨越介入空间之前,终端可以接近到一个非常短的距离;第二、受损电介质的闭合或修复,或者换句话说,绝缘能力的恢复,应该是瞬时的,以便将浪费主要发生的时间减少到最小;第三、介质应该是化学惰性的,以便尽可能地减少电极的退化,并防止可能导致热量产生或能量损失的化学过程;第四、在施加电压的情况下,介质的让路不应该是柔软的,而应该是非常突然的,并且具有碎裂的性质,类似于固体的碎裂,如同在老虎钳中挤压一块玻璃时的情况,第五,最重要的是,介质应该使得电弧在形成时被限制到最小可能的线性尺寸,并且不允许扩散或扩展。作为朝着这些理论要求方向迈出的一步,我在我的一些电路控制装置中采用了高绝缘质量的流体,如液态烃,并在靠近和远离电路控制器接触点的两个过程之间,最好以很大的速度用力推进该液态烃。通过使用这种液体绝缘体,获得了非常显著的优点;但是,虽然以这种方式达到了上述中的一些要求,但是仍然存在某些缺陷,特别是由于与真空空间相同的绝缘液体,,但允许电弧在长度和粗度上扩展,尽管程度较小,从而穿过所有程度的电阻,并或多或少地造成相当大的能量浪费。为了克服这个缺陷并更接近于达到电路控制装置最有效工作所需的理论条件,我最终被引导使用承受能巨大压力的一种流体绝缘介质。

The application of great pressure to the medium in which the make-and-break is made secures a number of specific advantages. One of these may be obviously inferred from well-established experimental facts, which demonstrate that the striking distance of an arc is approximately inversely proportional to the pressure of the gaseous medium in which it occurs; but in view of the fact that in most cases occurring in practice the striking distance is very small, since the difference of potential between the electrodes is usually not more than a few hundred volts, the economical advantages resulting from the reduction of the striking distance, particularly on approach of the terminals, are not of very great practical consequence. By far the more important gain I have found to result from an effect which I have observed to follow from the action of such a medium when under pressure upon the arc—namely, that the cross-section of the latter is reduced approximately in an inverse ratio to the pressure. As under conditions in other respects the same the waste of energy in an arc is proportional to its cross-section, a very important gain in economy generally results. A feature of great practical value lies also in the fact that the insulating power of the compressed medium is not materially impaired even by considerable increase in temperature, and, furthermore, that variations of pressure between wide limits do not interfere notably with the operation of the circuit-controller, whereas such conditions are fatal drawbacks when, for instance, Poggendorff's method of insulating the terminals is used. In many other respects, however, a gas under great compression nearly fulfills the ideal requirements above mentioned, as in the sudden breaking down and quick restoration of the insulating power, and also in chemical inertness, which by proper selection of the gas is easily secured.

向进行通断的介质施加巨大的压力保证了许多特定的优点。其中一个可以从公认的实验事实中显而易见地推断出来,这些实验事实证明电弧的起弧距离与电弧所在的气体介质的压力近似成反比;但是考虑到在实践中发生的大多数情况下,起弧距离非常小,因为电极之间的电位差通常不超过几百伏,所以由起弧距离的减小产生的经济优势,特别是在接近终端时,没有非常大的实际意义。到目前为止,我发现更重要的收获来自于一种效应,我观察到这种介质在受压时在电弧上的作用——即,后者的横截面与压力近似成反比地减小。因为在其它方面的条件相同的情况下,电弧中的能量损耗与其横截面成正比,因此通常会产生非常重要的经济效益。具有很大实用价值的特征还在于,即使温度显著升高,被压缩的介质的绝缘能力

也不会受到实质性损害，此外，宽范围内的压力变化不会显著干扰电路控制器的运行，而当使用例如波根多夫的绝缘终端方法时，这种情况是致命的缺点。然而，在许多其他方面，在大压缩下的气体几乎满足以上提到的理想要求，如在绝缘能力的突然破坏和快速恢复方面，以及化学惰性方面，这是通过正确选择气体容易保证的。

In carrying out my invention the medium under pressure may be produced or maintained in any proper manner, the improvement not being limited in this particular to any special means for the purpose. I prefer, however, to secure the desired result by enclosing the circuit-controller, or at least so much of the same as shall include the terminals, in a chamber or receptacle with which communicates a small reservoir containing a liquefied gas. For purpose of illustration this particular manner of carrying out the invention is described herein.

在实施我的发明时，受压介质可以以任何适当的方式产生或维持，这种改进不限于为此目的的任何特定手段。然而，我更喜欢通过将电路控制器，或至少包含终端的电路控制器，密封到与容纳液化气体的小容器连通一个的隔壁或容器中来保证预期的结果。为了说明的目的，这里描述了执行本发明的这种特定方式。

While the improvement is applicable generally to circuit-controllers, the best results will be secured by the use of devices in which a high relative speed between the terminals is obtainable, and with this special object in view I have devised a novel circuit-controller which, though belonging to the class of which I have shown a typical form in my application for patent filed December 2, 1897, Serial No. 660,518 differs in certain particulars of construction, which will be understood from the following comparison: In the previously-described form of said circuit-controllers a rotary receptacle, carrying within it a series of spaced conductors, is driven at a high speed by a suitable motor. Mounted within and concentrically with the receptacle, but capable of free independent rotation with respect thereto, is a body which during the rotation of the receptacle is retarded or restrained against rotation by the application of a suitable force. This body carries a tube or duct which takes up at one end a fluid conductor contained in the receptacle and rotating with the same and discharges it from the other end against the rotating spaced conductors.

虽然这种改进通常适用于电路控制器，但最好的结果将通过在终端之间使用能获得高的相对速度的装置来保证，并且考虑到这一特殊目的，我已经设计了一种新颖的电路控制器，虽然该装置属于我在1897年12月2日提交的序列号为660,518的专利申请中已经展示的典型形式，但在结构的某些细节上不同，这将从下面的比较中理解：在前述形式的所述电路控制器中，旋转容器由适合的电动机高速驱动，该旋转容器内带有一连串被间隔开的导体。被安装在容器内并且与容器同心，但是能够相对于容器自由独立旋转的一个主体，在容器旋转期间，通过施加适当的力，该主体被阻滞或被限制旋转。该主体带有一个管或导管，该管或导管在一端带走被容纳在容器中并与容器一起旋转的流体导体，并从另一端朝着旋转中的被间隔开的导体射出流体。

While an apparatus thus constructed is very efficient and performs the work required of it in a highly-satisfactory manner, it is nevertheless subject to certain limitations, arising mainly from the amount of work which the conducting fluid is required to perform and which increases with the speed. With the object of overcoming objections that might lie to this form of circuit-controller in the particular referred to, I devised the form of instrument shown herein. The features which more particularly distinguish

this form are the following: I employ a closed stationary receptacle within which is mounted a body that is capable of being rotated in any way—as, for example, by the drag or pull upon it of an external field of force or a magnet rotated bodily. The rotary body imparts rotation to a series of spaced conductors within the receptacle and also operates as a pump to maintain a flow of conducting fluid through one or more stationary ducts and from the same against the rotating conductors.

虽然如此构造的装置非常有效，并且以非常令人满意的方式执行所需的工作，但是它仍然受到某些限制，这些限制主要来自于导电流体需要执行的工作量，并且该工作量随着速度的增加而增加。为了克服可能存在于这种电路控制器形式中的缺陷，我设计了这里所展示的仪器形式。更具体地区分这种形式的特征如下：我使用了一个封闭的静态容器，其中安装了一个能够以任何方式旋转的物体——例如，通过外部力场的拖曳或拉动，或整体旋转的磁体。该旋转体将旋转施加在容器中的一连串导体上，并像一个泵一样维持着射向旋转中的导体的一股导电流体流束，该流束来自一个或多个静态导管。

The details of this apparatus will be described by reference to the accompanying drawing, which is a vertical central section of the circuit-controller complete.

该设备的细节将参照附图进行描述，该附图是完整的电路控制器的垂直中心截面图。

A is a receptacle, of iron, steel, or other proper material, with a head B, secured by a gas-tight insulating-joint. Within this receptacle is contained the circuit-controller, which, in so far as the main feature of my present invention is concerned, may be of any desired construction, but which, for the reason stated above, is of the special character shown. A spindle C is screwed or otherwise secured centrally in the head B, and on this is mounted on antifriction-bearings a body to which rotary motion may be imparted. The construction of the device in this particular and the means for imparting rotation to the said body may be greatly varied; but a convenient means for accomplishing this is to secure to the rotary sleeve D a laminated magnetic core E and place around the portion of the head B which contains it a core F, provided with coils and constituting the primary element of a motor capable of producing a rotary field of force which will produce a rapid rotation of the secondary element or core E. To the depending end of the sleeve D is secured a conductor G, usually in the form of a disk with downwardly-extending teeth or peripheral projections H. To the sleeve or the disk G is also attached, but insulated therefrom, a shaft T, having a spiral blade and extending down into a well or cylindrical recess in the bottom of the receptacle. One or more ducts or passages J lead from the bottom of this well to points near the path of the conducting-teeth H, so that by the rotation of the screw I a conducting fluid, which runs into the well from the receptacle, will be forced up through the duct or ducts, from which it issues in a jet or jets against the rotating conductor. To facilitate this operation, the well is surrounded by a flange K, containing passages L, which permit the conducting fluid to flow from the receptacle into the well, and having beveled sides which serve as a shield to deflect the fluid expelled from the ducts through the spaces in the conductor to the bottom of the receptacle.

A 是一个容器，由铁、钢或其他合适的材料制成，带有由气密绝缘接头固定的一个头部 B。在这个容器内容纳了电路控制器，就我的发明的主要特征而言，它可以是任何所需的结构，但是由于上述原因，它具有所示的特定特征。心轴 C 被螺纹连接或以其他方式被固定在头部 B 的中心，并且其上安装有滚珠轴承，旋转运动可以被传递到该滚珠轴承上。在这个特例中，该装置的结构和用于将旋转传递给所述主体的装置可以有很大的变化；但是实现这一点

的方便措施是将层叠磁芯 E 固定到旋转套筒 D 上，并在容纳磁芯的头部 B 的部分周围放置磁芯 F，磁芯 F 配有线圈并构成能够产生旋转磁场的电动机的初级组件，旋转磁场将产生次级组件或磁芯 E 的快速旋转。导体 G 被固定到套管 D 的悬端，该导体通常为具有向下延伸的齿或周边突起 H 的圆盘形式。套筒或盘 G 还连接有轴 T，但与套筒绝缘，轴 T 具有一个螺旋叶片并向下延伸到容器底部的井中或圆柱形凹槽中。一个或多个导管或通道 J 从该井的底部通向导电齿 H 的路径附近的点，以便利用螺杆 I 的旋转，从容器流入井内的导电流体将被强制向上通过一个或多个导管，并从那里以一股或多股射流射向旋转中的导体。为了便于这种操作，井被凸缘 K 包围，凸缘 K 容纳着通道 L，通道 L 允许导电流体从容器流入井内，凸缘 K 具有用作屏蔽的斜侧面，以将从导管排出的流体在穿过导体中的空间后偏转到容器的底部。

M is any suitable reservoir communicating with the interior of the main receptacle and containing a liquefied gas, such as ammonia, which maintains a practically inert atmosphere under pressure in the receptacle.

M 是与主容器内部连通的任何合适的储液器，它容纳着液化气体，例如氨，该液化气体在容器中在压力下保持几乎惰性的气氛。

Preferably, though mainly as a matter of convenience, the receptacle M is a metal cup with a hollow central stem N, the opening for the passage of gas being controlled by a screw-valve in the top of the cup. The said cup is screwed onto the end of the spindle C, through which is a passage O, leading into the interior of the receptacle A.

尽管主要是为了方便，容器 M 最好是具有中空中心杆 N 的金属杯，用于气体通过的开口由杯顶部的一个螺旋阀控制。所述杯被拧到心轴 C 的端部，通道 O 穿过该心轴 C，通向容器 A 的内部。

The receptacle A and the conducting fluid, which is generally mercury, being normally insulated from the head B and the parts attached and supported thereby, are connected to one part of the circuit to be controlled.

容器 A 和通常是水银的导电流体（通常与头部 B 和由此连接和支撑的部件绝缘）连接到要控制的电路的一部分。

The other circuit connection is made by a conductor P to any part of the head, so that when the core E and conductor G are rotated the circuit will be completed between the two insulated parts of the receptacle through the jet or jets of conducting fluid whenever they impinge upon the said conductor.

另一个电路连接由导体 P 连接到头部的任何部分来完成，从而当磁芯 E 和导体 G 被转动时，每当导电流体的射流撞击所述导体，电路将通过导电流体的射流在容器的两个被绝缘部分之间完成。

To insure a good electrical connection between the sleeve D and the spindle C, I provide in the former a small chamber R, which contains mercury, and into this the end of the spindle C extends.

为了确保套筒 D 和心轴 C 之间的良好电连接，我在前者中提供了一个小隔间 R，它容纳水银，并且心轴 C 的端部延伸到该隔间中。

The special advantages of this particular form of circuit-controller heretofore referred to will now more readily appear. The mass and weight of the rotating parts are greatly reduced and a very high speed of rotation obtained with small expenditure of energy. The power required to maintain the jets of conducting fluid is, moreover, very small.

迄今为止提及的这种特定形式的电路控制器的特殊优点现在将更容易地显现出来。旋转部件的质量和重量大大降低，并且以小的能量消耗获得非常高的旋转速度。此外，维持导电流体喷射所需的功率非常小。

Having, now described my invention, what I claim is—

在描述了我的发明后，我主张—

1. The combination with a closed receptacle, of a circuit-controller contained therein and surrounded by an inert insulating medium under pressure.

1、一个电路控制器与一个封闭容器的组合，该电路控制器被封装在该容器内，并被加压的惰性绝缘介质所包围。

2. The combination with a closed receptacle, of a circuit-controller contained therein and means for maintaining within said receptacle an inert atmosphere under pressure.

2、一个封闭容器、被容纳在该容器中的一个电路控制器和用于在所述容器内保持惰性大气处在压力下的装置的组合。

3. The combination with a closed receptacle, of a circuit-controller contained therein, and a vessel containing a liquefied inert gas, and communicating with the interior of the receptacle.

3、一个封闭容器、被容纳在该容器中的一个电路控制器和容纳一种液化惰性气体并与容器内部连通的容器的组合。

4. The combination with a circuit-controlling mechanism, one part or terminal of which is a conducting fluid, such as mercury, of a receptacle enclosing the same and means for maintaining an inert gas under pressure in the receptacle.

4、存在一个组合，包括：一个电路控制机械装置；该装置的一部分或一个终端是一种导电流体，如水银；容纳该导电流体的一个容器和用于在该容器中保持惰性气体处于压力下的装置。

5. The combination with a conductor or series of conductors constituting one terminal of a circuit-controller, means for maintaining a stream or jet of conducting fluid as the other terminal with which the conductor makes intermittent contact, a closed receptacle containing the terminals, and means for

maintaining an inert atmosphere under pressure in the receptacle.

5、存在一个组合，包括：一个导体或一连串导体，构成了电路控制器的一个终端；用于维持导电流体流束或射流作为一种导体间歇地接触另一个终端的装置；容纳这些终端的一个封闭容器；以及用于在该容器中保持惰性气体处于压力下的装置。

6. A device for making and breaking an electric circuit comprising, in combination, means for maintaining a jet or stream of conducting fluid which constitutes one terminal, a conductor or conductors making intermittent contact with the jet and constituting the other terminal and a receptacle enclosing and excluding oxygen from the said terminals.

6、一种用于接通和断开电路的装置，这种组合包括：用于维持构成一个终端的导电流体的射流或流束的装置；与射流间歇接触并构成另一个终端的一个或多个导体；以及封闭所述终端并从所述终端排除氧气的容器。

7. The combination with a receptacle, of a conductor or series of spaced conductors mounted therein, a motive device for rotating said conductors, one or more nozzles for directing a stream or jet of fluid against the conductor, and a force-pump in direct connection with the conductor for maintaining a circulation of conducting fluid contained in the receptacle through the nozzle or nozzles, the conductor and the fluid constituting respectively the terminals of a circuit-controller.

7、存在一个组合，包括：一个容器；被安装在该容器中的一个导体或一连串被间隔开的导体；用于旋转所述导体的一个动力装置；一个或多个用于将流体流束或射流引向导体的喷嘴；以及与导体直接连接的压力泵，用于通过一个或多个喷嘴维持被容纳在容器中的导电流体的循环；分别构成一个电路控制器的不同终端的导体和流体。

8. The combination of a casing, a conductor or series of spaced conductors mounted therein, a motor for rotating the same, one or more ducts or channels from a receptacle containing a conducting fluid and directed toward the conductors, and a screw operated by the motor for forcing the conducting fluid through the duct or ducts against the conductors, the conductors and the fluid constituting the terminals of an electric-circuit controller.

8、存在一个组合，包括：一个外壳；安装在该外壳中的一个导体或一连串被间隔开的导体；用于旋转该导体的一个电动机；来自容纳一种导电流体的容器并指向导体的一个或多个导管或通道；以及由电动机操作的螺杆，该螺杆用于推进导电流体通过一个或多个对准导体的导管；分别构成一个电路控制器的不同终端的导体和流体。

9. The combination with a receptacle containing a conducting fluid, of a conductor mounted within the receptacle, means for rotating the same, a screw rotating with the conductor and extending into a well in which the fluid collects, and a duct or ducts leading from the well to points from which the fluid will be directed against the rotating conductor.

9、存在一个组合，包括：容纳一种导电流体的容器；安装在该容器内的一个导体；用于旋转该导体的装置；与导体一起旋转并延伸到收集流体的井中的一个螺杆；以及一个或多个导管，用于将流体从井中引导到对准旋转中的导体的位置。

10. The combination with the receptacle, of a spindle secured to its head or cover, a magnetic core mounted on the spindle within the receptacle, means for rotating said core, a conductor rotated by the core, and a pumping device, such as a screw rotated by the core and operating to maintain a jet or jets of conducting fluid, against the conductor, when in rotation.

10、存在一个组合，包括：一个容器；被固定在该容器头部或盖子上的心轴；安装在容器内的心轴上的磁芯；用于旋转所述磁芯的装置；由该磁芯旋转的导体；以及一个泵送装置，例如由磁芯旋转的螺杆，当旋转时，该泵送装置用于维持导电流体对着导体的一个或多个射流。

NIKOLA TESLA.

尼古拉·特斯拉

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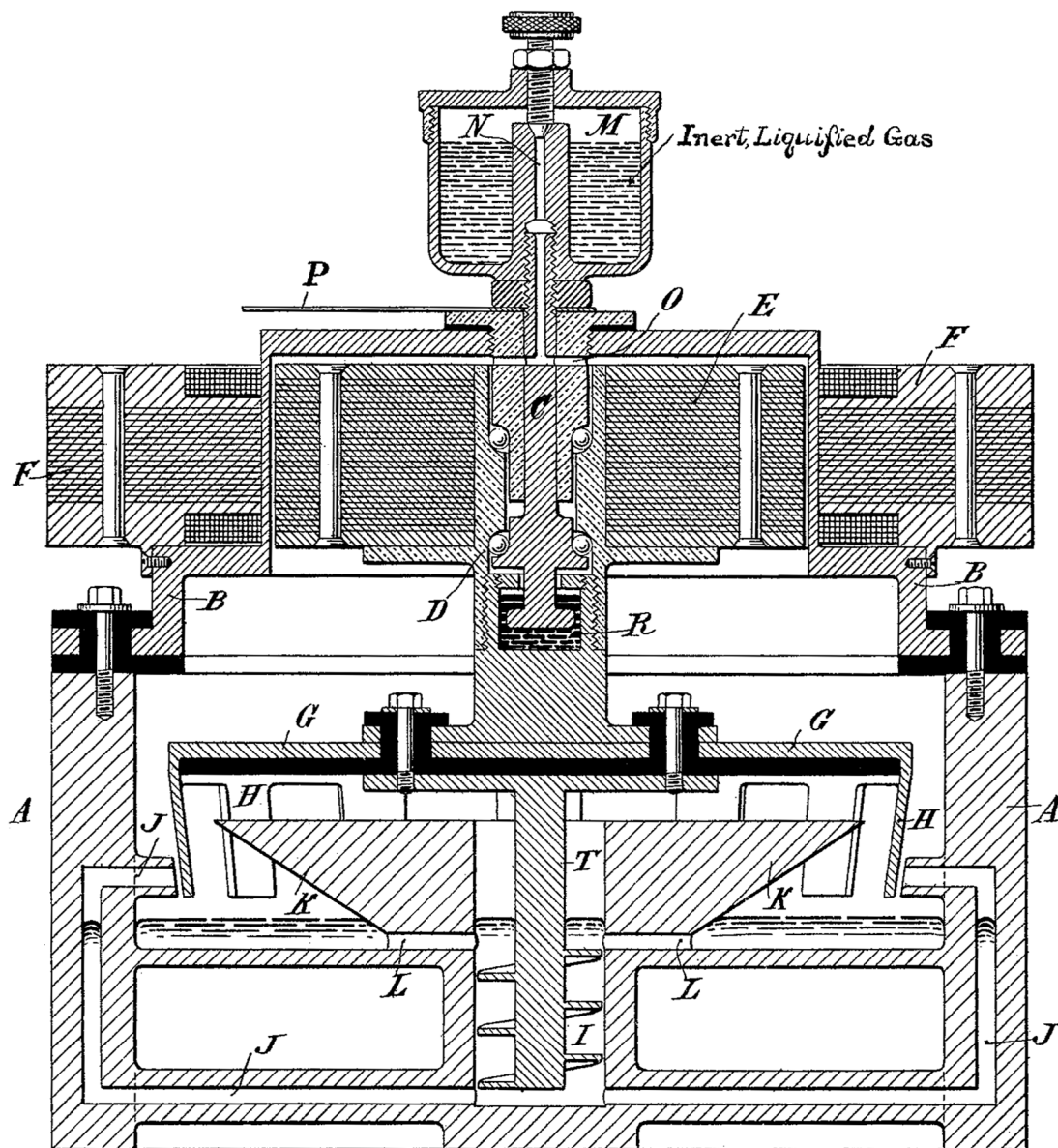
No. 611,719.

Patented Oct. 4, 1898.

N. TESLA.
ELECTRICAL CIRCUIT CONTROLLER.

(Application filed Dec. 10, 1897.)

(No Model.)



Witnesses:
Raphaël Petter
Edwin B. Hopkinson.

Nikola Tesla, Inventor
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ELECTRIC-CIRCUIT CONTROLLER.

电路控制器

NIKOLA TESLA, OF NEW YORK, N. Y.

纽约州纽约市的尼古拉·特斯拉

SPECIFICATION forming part of Letters Patent No. 613,735, dated November 8, 1898.

Application filed April 19, 1898. Serial No. 678,127. (No model.)

该说明书形成了颁发于 1898 年 11 月 8 日编号为 613,735 的专利证书的一部分。

该申请于 1898 年 4 月 19 日提交。序列号为 678,127。(没有模型)

To all whom it may concern:

致所有相关人士:

Be it known that I, NIKOLA TESLA, residing at New York, in the county and State of New York, have invented certain new and useful Improvements in Electrical-Circuit Controllers, of which the following is a specification, reference being had to the drawings accompanying and forming a part of the same.

众所周知，我，尼古拉·特斯拉，一名美国公民，居住在纽约州纽约郡纽约市，在电路控制器方面已经发明了某些新的和有用的改进，以下是该发明一个说明书，必须参考随附的图纸，它已形成了该说明书的一部分。

In the electrical system or combination of apparatus for the conversion of electrical energy by means of the discharges of a condenser invented and heretofore described by me the means employed for making and breaking the electric circuit, though performing a subordinate function, may from the peculiar conditions which exist become a highly important consideration, not only as regards their practicability and durability, but also the economy in the operation of the system or apparatus. Of such importance is this consideration that for the most efficient and reliable operation of my said system I have found it necessary to devise special appliances for making and breaking the circuit which differ materially in construction and mode of operation from any previously-existing devices of this character of which I am aware. In the forms of such apparatus which I have produced at least one of the terminals is a conducting fluid, while the other is usually a solid conductor or series of conductors, both being preferably enclosed in a gas-tight receptacle and brought by rotary movement into rapidly intermittent contact. I have shown and described typical forms of such circuit-controllers in applications Serial No. 660,518, filed December 2, 1897; Serial No. 639,227, filed June 3, 1897, and Serial No. 671,897, filed February 28, 1898.

在电气系统或装置的组合中，通过我发明的并在此之前描述的电容器的放电来转换电能，用于接通和断开电路的装置，虽然执行从属功能，但该装置可能从存在的特有条件变成了一个高度重要的考虑，不仅关乎它们的实用性和耐久性，而且关乎系统或装置运行的经济性。这

种考虑对于我的所述系统的最有效和最可靠的运行是如此的重要,所以我发现有必要设计特殊的装置来接通和断开电路,它在结构和运行模式上与我所知道的任何先前存在的这种特征的装置有实质性的不同。在我所生产的这种形式的装置中,至少一个终端是导电流体,而另一个终端通常是一个固体导体或一连串导体,两者最好都被密封在一个气密容器中,并通过旋转运动快速间歇地接触。我已经在 1897 年 12 月 2 日提交的序列号为 660,518 的申请中展示和描述了这种电路控制器的典型形式;另外还有 1897 年 6 月 3 日提交的序列号为 639,227 和 1898 年 2 月 28 日提交的序列号为 671,897 的申请中也展示和描述了这种电路控制器。

The invention, subject of my present application, pertains to apparatus of this class and involves certain improvements in the construction and mode of operation of the same which have primarily for their object to secure a greater relative speed between the two terminals, whereby the periods of make-and-break, during which occurs the chief loss of energy, may be materially shortened and also a higher frequency of current impulses secured. A brief consideration of the forms of circuit controller of this general kind which I have heretofore shown and described will conduce to a better understanding of the principles followed in the construction of the apparatus upon which my present application is based and of the primary object which I have in view—to increase the relative speed of the two terminals in approaching and receding from each other.

作为本申请主题的本发明属于这种类型的装置,并涉及对该装置的结构和操作模式的某些改进,其主要目的是确保两个终端之间更大的相对速度,从而可以大大缩短产生主要能量损失的接通和断开时间,并确保一个更高的电流脉冲频率。对我在此之前已经展示和描述的这种一般类型的电路控制器的形式的简要考虑将有助于更好地理解在我的本申请所基于的装置构造中所遵循的原理以及我所考虑的主要目的——增加两个终端彼此接近和远离的相对速度。

In some forms of the circuit-controllers heretofore described by me I employ a closed receptacle capable of being maintained in rapid rotation. Within this receptacle is mounted a body the rotation of which is retarded or prevented and which carries a tube or duct which takes up a conducting fluid from the receptacle when the latter is rotated and directs the said fluid against a conductor or series of spaced conductors carried by the rotating receptacle. This apparatus, while effective to a high degree and possessing many advantages over previously-existing forms, is nevertheless subject to certain limitations as to efficiency, having regard to the speed at which the receptacle is rotated, for not only may an undue loss of energy result from rotating the receptacle, but also from the unnecessarily-rapid movement of the conducting fluid. With a view to improving the apparatus in these particulars I devised forms in which the receptacle was stationary and the interior terminal conductor rotated, and by this means I reduced the mass and weight of the moving parts. I also employed a device in the nature of a pump, which formed a part of the circuit-controller proper and was operated by the motor used for rotating the conductor, and thus maintained a flow of conducting fluid from ducts in the receptacle against the rotating conductor with no greater speed than required for efficient operation. By such an apparatus it is not only possible to secure a higher relative speed between the two terminals, but to do this with a smaller expenditure of mechanical energy. To still further increase the relative speed of the terminals, I now provide for rotating each of the terminals with respect to the other, so that the rate of mutual contacts is very greatly increased.

在我之前描述的电路控制器的一些形式中,我采用了能够保持快速旋转的一个封闭容器。在

该容器内安装有一个主体，该主体的旋转被阻滞或阻止，并且该主体具有一个管或导管，当容器旋转时，该管或导管从容器中带走一种导电流体，并且将所述流体导向由旋转容器携带的一个导体或一连串被间隔开的导体。尽管这种装置在很大程度上是有效的，并且相对于以前存在的形式具有许多优点，但是考虑到容器旋转的速度，这种装置在效率方面受到一定的限制，因为不仅旋转容器会导致过度的能量损失，而且导电流体的不必要的快速运动也会导致过度的能量损失。为了在这些细节上改进设备，我设计了容器静止而内部终端导体旋转的形式，通过这种方式我减少了移动部件的质量和重量。我还采用了一种泵性质的装置，该装置形成了电路控制器本身的一部分，并由用于旋转导体的电动机来操作，从而维持来自容器中导管的导电流体相对于旋转导体的流动，其速度不大于有效运行所需的速度。通过这种设备，不仅可以确保两个终端之间的较高相对速度，而且可以用较小的机械能消耗来实现这一点。为了进一步增加不同终端的相对速度，我现在提供给每个终端相对于另一个旋转，以便极大地增加相互接触的速率。

Obviously various means may be employed for rotating the conductors, or, in general, the two essential parts which by their movement produce a make and break; but in the annexed drawings I have only shown such forms of the apparatus as best illustrate the present improvement.

显然，可以采用各种方法来旋转导体，或者一般来说，通过它们的运动产生接通和断开的两个必不可少的部分；但是在附图中，我仅展示了这种形式的装置，以最好地说明当前的改进。

Figure 1 is a central vertical section of a circuit-controller comprising a conductor or series of conductors forming one terminal and means for maintaining a jet or jets of conducting fluid constituting the other terminal, which are arranged to be rotated in opposite directions. Fig. 2 is a similar view of a modified form of circuit-controller.

图 1 是一个电路控制器的一个中心垂直剖面图，该电路控制器包括形成一个终端的一个导体或一连串导体，以及用于维持构成另一个终端的一股或多股导电流体射流的装置，它们被设置成沿相反方向旋转。图 2 是电路控制器的修改形式的一个类似视图。

A designates a casting of cylindrical form within which is a standard or socket B, in which is mounted a vertical spindle C, carrying the circuit-controlling mechanism. The said mechanism is contained in a receptacle D, of iron or steel, the top or cover of which is composed of an annular plate E and a cap or dome F, the latter being of insulating material or of a metal of comparatively high specific resistance, such as German silver. The receptacle D as a whole is made air-tight and any suitable means may be employed to effect its rotation, the particular device shown for this purpose being an electromagnetic motor, one element, G, of which is secured to the spindle C or receptacle D and the other, H, to the box or case A. Within the receptacle D and secured to the top of the same, but insulated therefrom, is a circular conductor K, with downwardly-extending projections or teeth L. This conductor is maintained in electrical connection with a plate M outside of the receptacle by means of screws or bolts N, passing through insulated gaskets in the top of the receptacle D. Within the latter is a standard or socket O, in which is mounted as spindle P, concentric with the axis of the receptacle.

A 表示一个圆筒形铸件，其内部是一个立柱或承口 B，其中安装了一个垂直轴 C，携带有电路控制机械装置。所述机械装置被容纳在铁质或钢质的容器 D 中，容器 D 的顶部或盖子由一个环形板 E 和一个帽或圆顶 F 组成，后者由绝缘材料或电阻系数相对较高的金属制成，

如锌白铜。容器 D 作为一个整体被制成气密的，并且可以采用任何合适的装置来实现其旋转，为此目的展示的特定装置是一个电磁电动机，其一个组件 G 被固定到心轴 C 或容器 D 上，而另一个组件 H 被固定到盒子或外壳 A 上。圆形导体 K 位于容器 D 内并固定到容器的顶部，但与顶部绝缘，该导体具有向下延伸的突起或齿 L。该导体通过穿过容器 D 顶部的绝缘垫圈的螺钉或螺栓 N 与容器外部的一个盘 M 保持电连接。在容器 D 之内是一个立柱或承口 O，其中安装有主轴 P，与承口的轴线同心。

Any suitable means may be provided for rotating the spindle P independently of the receptacle D; but for this purpose I again employ an electromagnetic motor, one element, Q, of which is secured to the spindle P within the receptacle D and the other, R, is secured to the box A and surrounds the cap or dome F, within which is mounted the armature Q.

可以提供任何合适的装置来独立于容器 D 旋转心轴 P；但是为了这个目的，我再次使用了电磁电动机，该电动机的一个组件 Q 被固定到容器 D 内的心轴 P 上，而另一个组件 R 被固定到外壳 A 上，并且围绕着帽或圆顶 F，电枢 Q 被安装在帽或圆顶 F 内。

Depending from the spindle P or the armature Q is a cylinder S, to which are secured arms T T, extending radially therefrom and supporting short tubes or ducts V between the peripheral walls of the receptacle D and the series of teeth or projections L.

从心轴 P 或电枢 Q 垂下的是一个圆筒 S，其上安装了臂 T T，它们从圆筒 S 径向延伸并支撑着在容器 D 的周壁和一系列齿或突起 l 之间的短的管或导管 V。

The tubes V have openings at one end in close proximity to the inner wall of the receptacle D and turned in a direction opposite to that in which the latter is designed to rotate and at the other end orifices which are adapted to direct a stream or jet of fluid against the projections L.

管 V 在靠近容器 D 内壁的一端具有开口，并且旋转方向与容器 D 的旋转方向相反，而在另一端具有孔口，该孔适于将流体流束或射流导向突起 L。

To operate the apparatus, the receptacle D, into which a suitable quantity of conducting fluid, such as mercury, is first poured, and the spindles P are both set in rotation by their respective motors and in opposite directions. By the rotation of receptacle D the conducting fluid is carried by centrifugal force up the sides or walls of the same and is taken up by the tubes or ducts V and discharged against the rotating conductors L. If, therefore, one terminal of the circuit be connected with any part of the receptacle D or the metal portions of the instrument in electrical connection therewith and the other terminal be connected to the plate M, the circuit between these terminals will be completed whenever a jet from one of the ducts V is discharged against one of the projections L and interrupted when the jets are discharged through the spaces between such projections. I have indicated the necessary circuit connections by wires X and X', connected, respectively, with a brush M', bearing upon the circular plate M, and a binding-post X", set in the frame or casing A.

为了操作该设备，首先将适当量的导电流体（例如水银）倒入容器 D 中，并且不同的心轴 P 都由它们各自的电动机沿相反的方向旋转。通过容器 D 的旋转，导电流体被离心力带至容器的侧面或侧壁上，并被管或导管 V 带走，并朝着旋转中的导体 L 射出。因此，如果电路

的一个终端与容器 D 的任何部分或与其电连接的仪器的金属部分连接，而另一个终端与盘 M 连接，则每当来自一个导管 V 的射流射向一个突起 L 时，这些终端之间的电路将被接通，当射流穿过这些突起之间的空间射出时，电路被中断。我已经通过导线 X 和 X'指出了必要的电路连接，导线 X 和 X'分别与倚靠在盘 M 上的电刷 M'和设置在框架或外壳 A 中的接线柱 X"连接。

In Fig. 2 a modified form of apparatus is shown and by means of which similar results are obtained. In this device the top and bottom A' of the receptacle are metal plates, while the cylindrical portion or sides A" is of insulating material, such as porcelain. Within the receptacle and preferably integral with the side walls A" are two annular troughs W W', which contain a conducting fluid B', such as mercury. Terminals C' C", passing through the bottom of the receptacle through insulating and packed sleeves, afford a means of connecting the mercury in the two troughs with the conductors of the circuit. Surrounding that portion of the device in which the troughs W W' lie is a core D', wound with coils D", arranged in any suitable and well-known manner to produce, when energized by currents of different phase, a rotating magnetic field in the space occupied by the two bodies of mercury. To intensify the action, a circular laminated core E' is placed within the receptacle. If by this or any other means the mercury is set in motion and caused to flow around in the troughs, and if a conductor be mounted in position to be rotated by the mercury, and when so rotated to make intermittent contact therewith, a circuit-controller may be obtained of novel and distinctive character and capable of many useful applications independently of the other natures which are embodied in the complete device which is illustrated. For the present purpose I provide in the center of the receptacle a socket in which is mounted a spindle P', carrying a disk G'. Depending from said disk are arms H', which afford bearings for a shaft K', supporting two star-shaped wheels L' L", arranged to make contact with the mercury in the two troughs, respectively. The shaft K' is mounted in insulated bearings, so that when both wheels are in contact with mercury the circuit connecting the terminals C' C" will be closed. The disk G' carries an annular core N', which is adapted to be maintained in rotation by a core O' and coils O", supported outside of the receptacle and preferably of the same character as those used for imparting rotation to the mercury; but the direction of rotation should be opposite to that of the mercury. The rate of rotation of the wheels L' L" depends upon the rate of relative movement of the mercury, and hence if the mercury be caused to flow in one direction and the wheels be carried bodily in the opposite direction the rate of rotation, and consequently the frequency of the makes and breaks, will be very greatly increased over that which would be obtained if the wheels L' L" were supported in a stationary bearing.

在图 2 中，展示了一种改进形式的装置，通过该装置可以获得类似的结果。在该装置中，容器的顶部和底部 A' 是金属板，而圆筒形部分或侧面 A" 是绝缘材料，例如陶瓷。在容器内并且最好与侧壁 A" 成一体的是两个环形槽 W W'，它容纳着导电流体 B'，如水银。终端 C' C" 穿过容器底部的绝缘包装套管，提供了将两个槽中的水银与电路导体连接的工具。围绕该装置的槽 W W' 所在部分的是一个磁芯 D'，该芯缠绕有线圈 D"，线圈 D" 以任何合适的众所周知的方式被布置，以在由不同相位的电流激励时，在由两个水银体占据的空间中产生一个旋转磁场。为了加强这种作用，在容器内放置一个圆形叠片铁芯 E'。如果通过这种或任何其它方式使水银运动，并使其在槽中流动，并且如果将一个导体安装在由水银推动旋转的位置上，并且当这样旋转以与其间歇接触时，可以获得具有新颖和独特特征的电路控制器，并且该电路控制器可以具有许多有用的应用，这些应用独立于在所示的完整设备中体现的其他特性。为了这个目的，我在容器的中心配备了一个承口，在该承口中安装了携带着盘 G' 的心轴 P'。从所述盘垂下的是臂 H'，它为轴 K' 提供轴承，轴 K' 支撑两个星形轮 L' L"，这两个轮被布置

成分别与两个槽中的水银接触。轴 K'被安装在绝缘轴承中，因此当两个轮子都与水银接触时，连接终端 C'C"的电路将闭合。盘 G'携带有环形磁芯 N'，该环形芯适于通过磁芯 O'和线圈 O"保持旋转，后两者被支撑在容器的外部，并且最好具有与用于使水银旋转的那些特性相同的特性；但是旋转的方向应该与水银的旋转方向相反。轮 L' L"的旋转速度取决于水银的相对运动速度，因此，如果使水银沿一个方向流动，而轮子整体沿相反方向运动，那么，与轮子 L' L"被支撑在固定轴承中相比，旋转速度和由此接通和断开的频率将大大增加。

It is obvious that by means of devices of the character described a rapid interruption of the circuit may be effected, while all the practical advantages which may be derived from enclosing the terminals or contacts in a closed receptacle are readily realized to the fullest extent.

很明显，借助于所述特征的装置，可以实现电路的快速中断，同时可以最大程度地容易地实现将终端或触点封入密封容器中所带来的所有实际优点。

Having now described my invention, what I claim is—

现在描述了我的发明，我主张的是—

1. In a circuit-controller, the combination with rigid and fluid conductors adapted to be brought intermittently into contact with each other, thereby making and breaking the electric circuit, of means for imparting rotary motion to both of said conductors, as set forth.

1、在一个电路控制器中，存在一个组合，包括：适于间歇地相互接触的刚性导体和流体导体，从而接通和断开电路；用于将旋转运动传递给所述两种导体的装置，如上所述。

2. In a circuit-controller, the combination with a receptacle containing a conducting fluid, means for imparting a movement of rotation to the fluid, and a conductor adapted to be rotated by the movement of said fluid and to thereby make and break electric connection with the fluid, as set forth.

2、在一个电路控制器中，存在一个组合，包括：容纳导电流体的一个容器；用于将旋转运动传递给流体的装置；以及一个导体，适于通过所述流体的运动被转动，因此与流体接通和断开电连接，如上所述。

NIKOLA TESLA.

尼古拉·特斯拉

Witnesses:

M. LAWSON DYER,

G. W. MARTLING.

见证人:

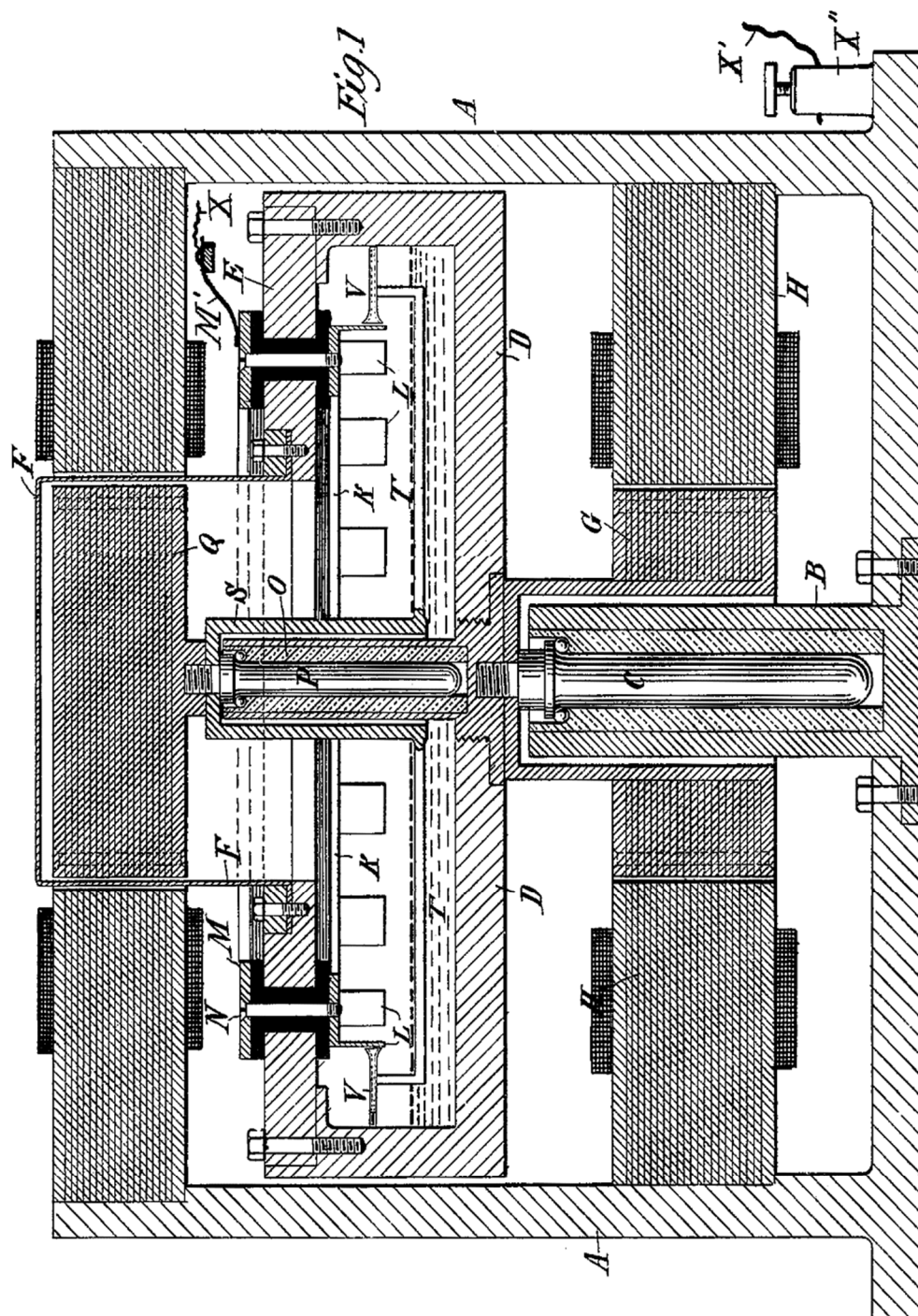
M.劳森·戴尔、G. W.玛特林。

N. TESLA.
ELECTRIC CIRCUIT CONTROLLER.

(Application filed Apr. 19, 1898.)

(No Model.)

2 Sheets—Sheet 1.



Witnesses:
Raphaël Vetter
Benjamin Miller.

Nikola Tesla, Inventor
by *Ken. Curtis & Wagon* Attys.

N. TESLA.
ELECTRIC CIRCUIT CONTROLLER.

(No Model.)

(Application filed Apr. 19, 1898.)

2 Sheets—Sheet 2.

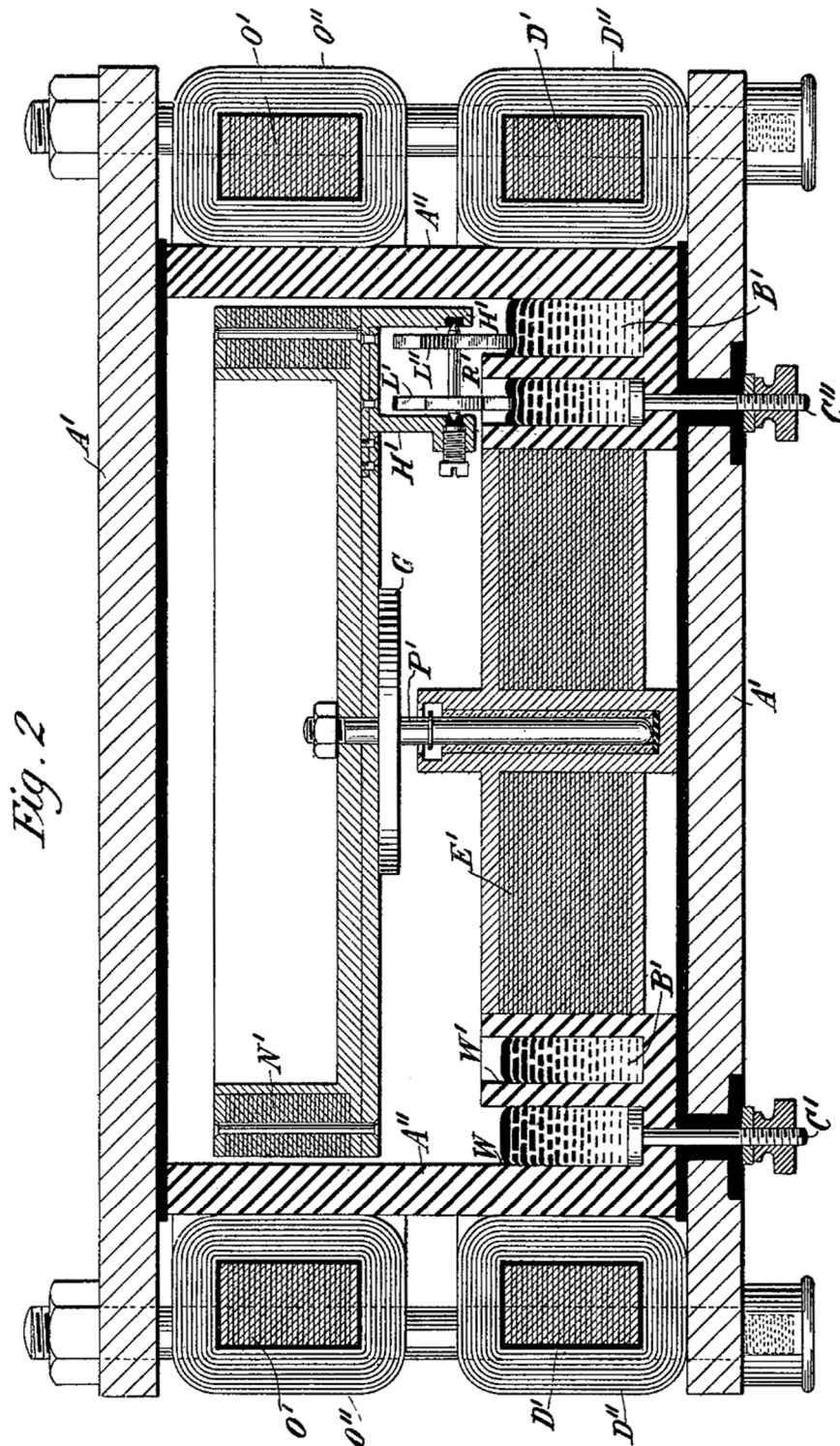


Fig. 2

Witnesses:
Raphaël Vetter
Benjamin Miller.

Nikola Tesla, Inventor
by Ken. Curtis & Page Attys.

APPARATUS FOR TRANSMITTING ELECTRICAL ENERGY

用于传输电能的装置

NIKOLA TESLA, OF NEW YORK, N. Y

纽约州纽约市的尼古拉·特斯拉

1,119,732. Specification of Letters Patent. Patented Dec. 1, 1914.

Application filed January 18, 1902. Serial No. 90,245. Renewed May 4, 1907. Serial No. 371,817.

专利证书 1,119,732 的说明书。1914 年 12 月 1 日获得专利。

申请日期是 1902 年 1 月 18 日。序列号 90,245。1907 年 5 月 4 日更新。序列号为 371,817。

To all whom it may concern:

致所有相关人士:

Be it known that I, NIKOLA TESLA, a citizen of the United States, residing in the borough of Manhattan, in the city, county, and State of New York, have invented certain new and useful Improvements in Apparatus for Transmitting Electrical Energy, of which the following is a specification, reference being had to the drawings accompanying and forming a part of the same.

众所周知，我，尼古拉·特斯拉，美国公民，居住在纽约州纽约郡纽约市的曼哈顿区，在用于传输电能的装置方面已经发明了某些新的和有用的改进，以下是该发明一个说明书，必须参考随附的参考图纸，它已形成了该说明书的一部分。

In endeavoring to adapt currents or discharges of very high tension to various valuable uses, as the distribution of energy through wires from central plants to distant places of consumption, or the transmission of powerful disturbances to great distances, through the natural or non-artificial media. I have encountered difficulties in confining considerable amounts of electricity to the conductors and preventing its leakage over their supports, or its escape into the ambient air, which always takes place when the electric surface density reaches a certain value.

在努力使甚高压的电流或放电适用于各种有价值的用途的工作中，如通过电线将能量从总动力厂分配到远处的用电场所，或通过自然媒介或非人工媒介将强大的扰动传输到很远的地方。我在将大量电力限制在导体上并防止其从支撑件上泄漏到或逃逸到环境空气中时遇到了困难，这总是在电的表面密度达到一定值时发生。

The intensity of the effect of a transmitting circuit with a free or elevated terminal is proportionate to the quantity of electricity displaced, which is determined by the product of the capacity of the circuit, the pressure, and the frequency of the currents employed. To produce an electrical movement of the required magnitude it is desirable to charge the terminal as highly as possible, for while a great quantity of electricity may also be displaced by a large capacity charged to low pressure, there are disadvantages

met with in many cases when the former is made too large. The chief of these are due to the fact that an increase of the capacity entails a lowering of the frequency of the impulses or discharges and a diminution of the energy of vibration. This will be understood when it is borne in mind, that a circuit with a large capacity behaves as a slackspring, whereas one with a small capacity acts like a stiff spring, vibrating more vigorously. Therefore, in order to attain the highest possible frequency, which for certain purposes is advantageous and, apart from that, to develop the greatest energy in such a transmitting circuit, I employ a terminal of relatively small capacity, which I charge to as high a pressure as practicable. To accomplish this result I have found it imperative to so construct the elevated conductor, that its outer surface, on which the electrical charge chiefly accumulates, has itself a large radius of curvature, or is composed of separate elements which, irrespective of their own radius of curvature, are arranged in close proximity to each other and so, that the outside ideal surface enveloping them is of a large radius. Evidently, the smaller the radius of curvature the greater, for a given electric displacement, will be the surface-density and, consequently, the lower the limiting pressure to which the terminal may be charged without electricity escaping into the air. Such a terminal I secure to an insulating support entering more or less into its interior, and I likewise connect the circuit to it inside or, generally, at points where the electric density is small. This plan of constructing and supporting a highly charged conductor I have found to be of great practical importance, and it may be usefully applied in many ways.

具有自由终端或高架终端的传输电路的影响强度与转移的电量成比例，该电量由电路的容量、压力和所用电流的频率的乘积决定。为了产生所需大小的电动运动，需要尽可能高地给终端充电，因为虽然大量的电力也可以被充到低压的大容量所取代，但是当容量太大时，在许多情况下会遇到缺点。这些主要是由于这样一个事实，即容量的增加必然导致脉冲或放电频率的降低和振动能量的减少。记住这一点就可以理解了，大容量的电路就像一个松弛的弹簧，而小容量的电路就像一个硬弹簧，振动更剧烈。因此，为了获得尽可能高的频率，这对于某些目的是有利的，除此之外，也是为了在这样一个发射电路中开发最大的能量，我使用一个相对小容量的终端，我充电到尽可能高的压力。为了实现这一结果，我发现必须如此构造高架导体，它必须有一个大半径曲率的外表面，使得电荷主要积聚其上，或者由独立的组件组成，这些独立的组件不管它们自己的曲率半径如何，都彼此紧密靠近地布置，因此，包围它们的外部理想表面具有大的半径。显然，对于一个给定的电位移，曲率半径越小，表面密度就越大，因此，在没有电逸出到空气中的情况下，终端可以充电的极限压力就越低。我在一个绝缘支架上固定这样一个终端，该绝缘支架或多或少地进入终端的内部，并且我同样将电路连接到其内部，或者通常在电密度小的点处。我发现这个建造和支撑高电荷导体的方案有很大的实际意义，它可以有效地应用于许多方面。

Referring to the accompanying drawing, the figure is a view in elevation and part section of an improved free terminal and circuit of large surface with supporting structure and generating apparatus.

参见附图，该图是具有支撑结构和发电设备的大表面的改进后的自由终端和电路的正视图和部分剖面图。

The terminal D consists of a suitably shaped metallic frame, in this case a ring of nearly circular cross section, which is covered with half spherical metal plates P P, thus constituting a very large conducting surface, smooth on all places where the electric charge principally accumulates. The frame is carried by a strong platform expressly provided for safety appliances, instruments of observation, etc., which in turn rests on insulating supports F F. These should penetrate far into the hollow space formed by the

terminal, and if the electric density at the points where they are bolted to the frame is still considerable, they may be specially protected by conducting hoods as H.

终端 D 由一个适当形状的金属框架组成, 在这种情况下, 该金属框架是一个横截面几乎为圆形的环, 其上覆盖有半球形金属板 PP, 从而构成一个非常大的导电表面, 在电荷主要聚集的所有地方都是光滑的。该框架由一个坚固的平台承载, 该平台专门为安全设备、观察仪器等装置提供方便, 而这些装置又放置在绝缘支撑 FF 上。这些支撑应该深入到由终端形成的中空空间中, 如果在螺栓固定到框架上的点处的电密度仍然相当大, 它们可以由导电罩特别保护, 如 H。

A part of the improvements which form the subject of this specification, the transmitting circuit, in its general features, is identical with that described and claimed in my original Patents Nos. 645,576 and 649,621. The circuit comprises a coil A which is in close inductive relation with a primary C, and one end of which is connected to a ground-plate E, while its other end is led through a separate self-induction coil B and a metallic cylinder B' to the terminal D. The connection to the latter should always be made at, or near the center, in order to secure a symmetrical distribution of the current, as otherwise, when the frequency is very high and the flow of large volume, the performance of the apparatus might be impaired. The primary C may be excited in any desired manner, from a suitable source of currents G, which may be an alternator or condenser, the important requirement being that the resonant condition is established, that is to say, that the terminal D is charged to the maximum pressure developed in the circuit, as I have specified in my original patents before referred to. The adjustments should be made with particular care when the transmitter is one of great power, not only on account of economy, but also in order to avoid danger. I have shown that it is practicable to produce in a resonating circuit as E A B B' D immense electrical activities, measured by tens and even hundreds of thousands of horse-power, and in such a case, if the points of maximum pressure should be shifted below the terminal D, along coil B, a ball of fire might break out and destroy the support F or anything else in the way. For the better appreciation of the nature of this danger it should be stated, that the destructive action may take place with inconceivable violence. This will cease to be surprising when it is borne in mind, that the entire energy accumulated in the excited circuit, instead of requiring, as under normal working conditions, one quarter of the period or more for its transformation from static to kinetic form, may spend itself in an incomparably smaller interval of time, at a rate of many millions of horse power. The accident is apt to occur when, the transmitting circuit being strongly excited, the impressed oscillations upon it are caused, in any manner more or less sudden, to be more rapid than the free oscillations. It is therefore advisable to begin the adjustments with feeble and somewhat slower impressed oscillations, strengthening and quickening them gradually, until the apparatus has been brought under perfect control. To increase the safety, I provide on a convenient place, preferably on terminal D, one or more elements or plates either of somewhat smaller radius of curvature or protruding more or less beyond the others (in which case they may be of larger radius of curvature) so that, should the pressure rise to a value, beyond which it is not desired to go, the powerful discharge may dart out there and lose itself harmlessly in the air. Such a plate, performing a function similar to that of a safety valve on a high pressure reservoir, is indicated at V.

构成本说明书主题的改进的一部分, 即发射电路, 其总体特征与我的原始专利 645,576 和 649,621 中描述的和要求主张保护的相同。该电路包括一个线圈 A, 它与一个初级线圈 C 有紧密的感应关系, 它的一端连接到接地板 E, 而它的另一端通过一个单独的自感线圈 B 和一

个金属圆筒 B' 连接到终端 D。为了确保电流的对称分布，与终端 D 的连接应始终在中心或中心附近进行，否则，当频率很高且电流很大时，设备的性能可能会受损。初级线圈 C 可以以任何期望的方式由一个合适的电流源 G 激励，电流源 G 可以是一个交流发电机或一个电容器，重要的要求是建立谐振条件，也就是说，终端 D 被充电到在电路中产生的最大电压力，正如我在前面提到的我的原始专利中所说明的。当变送器是一个大功率的机器时，应特别小心地进行调节，这不仅是为了经济，也是为了避免危险。我已经证明了在一个谐振电路（如 E A B B' D）中产生巨大的电活动是可行的，能测量到几万马力甚至几十万马力，在这种情况下，如果最大压力点转移到终端 D 的下方，一个火球可能会沿着线圈 B 爆发，摧毁支撑 F 或其他任何东西。为了更好地理解这种危险的性质，应该说明的是，这种破坏性的行动可能会以不可想象的暴力发生。在激发电路中积累的全部能量可能以数百万马力的速度在一个无比小的时间间隔内耗尽自己，而不是像在正常工作条件下那样需要四分之一或更多的周期来将这种能量从静态形式转变为动态形式，当记住这一点时，这种暴力将不再令人惊讶。当发射电路被强烈激励时，以任何方式或多或少导致外加振荡突然比自由振荡更快时，容易发生事故。因此，可取的做法是以微弱且稍慢的外加振动开始调整，逐渐加强和加快它们，直到设备已经处于完美的控制之下。为了增加安全性，我在一个方便的地方，最好是在终端 D 上，提供一个或多个组件或板，这些组件或板具有稍微更小的曲率半径或者或多或少地突出于其他组件或板（在这种情况下，它们可以具有更大的曲率半径），从而，如果压力上升到不希望超过的值，强大的放电可以在那里冲出并且在空气中无害地消失。这种板的功能类似于高压储罐上的安全阀，用 V 表示。

Still further extending the principles underling my invention, special reference is made to coil B and conductor B'. The latter is in the form of a cylinder with smooth or polished surface of a radius much larger than that of the half spherical elements P P, and widens out at the bottom into a hood H, which should be slotted to avoid loss by eddy currents and the purpose of which will be clear from the foregoing. The coil B is wound on a frame or drum D' of insulating material, with its turns close together. I have discovered that when so wound the effect of the small radius of curvature of the wire itself is overcome and the coil behaves as a conductor of large radius of curvature, corresponding to that of the drum. This feature is of considerable practical importance and is applicable not only in this special instance, but generally. For example, such plates at P P of terminal D, though preferably of large radius of curvature, need not be necessarily so, for provided only that the individual plates or elements of a high potential conductor or terminal are arranged in proximity to each other and with their outer boundaries along an ideal symmetrical enveloping surface of a large radius of curvature, the advantages of the invention will be more or less fully realized. The lower end of the coil B—which, if desired, may be extended up to the terminal D—should be somewhat below the uppermost turn of coil A. This, I find, lessens the tendency of the charge to break out from the wire connecting both and to pass along the support F'.

进一步扩展本发明的原理，特别参考线圈 B 和导体 B'。后者是具有光滑或抛光表面的圆柱体形式，其半径远大于半球形组件 P P 的半径，并且在底部变宽成罩 H，该罩应该开槽以避免涡流损耗，并且其目的将从前述内容中说明。线圈 B 缠绕在绝缘材料制成的框架或滚筒 D' 上，其相邻的匝圈紧靠在一起。我已经发现，当如此缠绕时，克服了导线本身的小曲率半径的影响，并且线圈表现为一个大曲率半径的导体，对应于滚筒的曲率半径。这一特点具有相当大的实际意义，不仅适用于这一特殊情况，而且适用于一般情况。例如，终端 D 的在 P P 处的这种板，尽管最好具有大的曲率半径，但不一定必须如此，只要一个高电位导体或终端的单个板或组件彼此靠近布置，并且它们的外边界沿着一个大曲率半径的理想的对称包络

面，本发明的优点将或多或少地完全实现。线圈 B 的下端——如果需要，可以延伸到终端 D 位置——应该稍微低于线圈 A 的最上匝。我发现，这减少了电荷从连接两者的导线中冲出并沿支架 F'传递的趋势。

Having described my invention, I claim:

描述了我的发明后，我主张：

1. As a means for producing great electrical activities a resonant circuit having its outer conducting boundaries, which are charged to a high potential, arranged in surfaces of large radii of curvature so as to prevent leakage of the oscillating charge, substantially as set forth.

1、作为用于产生大的电活动的一种工具，具有其外部导电边界的一个谐振电路，这些导电边界被充电到一个高电势，该高电势被布置在大曲率半径的表面中，以防止振荡电荷的泄漏，基本上如所述。

2. In apparatus for the transmission of electrical energy a circuit connected to ground and to an elevated terminal and having its outer conducting boundaries, which are subject to high tension, arranged in surfaces of large radii of curvature substantially as, and for the purpose described.

2、在用于电能传输的装置中，被连接到一个高架终端的一个接地电路，该接地电路具有其外部导电边界，该外部导电边界承受高电压，该高电压被布置在大曲率半径的表面上，基本上用于所述目的。

3. In a plant for the transmission of electrical energy without wires, in combination with a primary or exciting circuit a secondary connected to ground and to an elevated terminal and having its outer conducting boundaries, which are charged to a high potential, arranged in surfaces of large radii of curvature for the purpose of preventing leakage and loss of energy, substantially as set forth.

3、在一种用于无电线传输电能的设备中的组合，它包括一个初级或激励电路、一个次级连接到接地以及一个高架终端，并且其外部导电边界被充电到高电势，该高电势被布置在大曲率半径的表面中，用于防止能量的泄漏和损失，基本上如所述。

4. As a means for transmitting electrical energy to a distance through the natural media a grounded resonant circuit, comprising a part upon which oscillations are impressed and another for raising the tension, having its outer conducting boundaries on which a high tension charge accumulates arranged in surfaces of large radii of curvature, substantially as described.

4、作为通过自然介质向远处的一个接地谐振电路传输电能的一种工具，它包括一个被施加振荡的部分和另一个用于升高电压的部分，该部分的外部导电边界被布置在大曲率半径的表面上，其上积聚有高压电荷，基本上如所述。

5. The means for producing excessive electric potentials consisting of a primary exciting circuit and a resonant secondary having its outer conducting elements which are subject to high tension arranged in proximity to each other and in surfaces of large radii of curvature so as to prevent leakage of the charge

and attendant lowering of potential, substantially as described.

5、用于产生过大电势的工具，它包括一个初级激励电路和一个谐振次级，谐振次级的外部导电组件承受高电压，这些导电组件相互靠近布置在大曲率半径的表面上，以防止电荷泄漏和伴随的电势降低，基本上如所述。

6. A circuit comprising a part upon which oscillations are impressed and another part for raising the tension by resonance, the latter part being supported on places of low electric density and having its outermost conducting boundaries arranged in surfaces of large radii of curvature, as set forth.

6、一种电路，包括施加振荡的部分和用于通过谐振提高张力的另一部分，后一部分被支撑在低电密度的地方，并且其最外面的导电边界被布置在大曲率半径的表面中，如上所述。

7. In apparatus for the transmission of electrical energy without wires a grounded circuit the outer conducting elements of which have a great aggregate area and are arranged in surfaces of large radii of curvature so as to permit the storing of a high charge at a small electric density and prevent loss through leakage, substantially as described.

7、在用于无线传输电能的装置中，接地电路的外部导电组件具有大的总面积，并且被布置在大曲率半径的表面中，从而允许在小的电密度下存储高压电荷，并且防止通过泄漏的损耗，基本上如所述。

8. A wireless transmitter comprising in combination a source of oscillations as a condenser, a primary exciting circuit and a secondary grounded and elevated conductor the outer conducting boundaries of which are in proximity to each other and arranged in surfaces of large radii of curvature, substantially as described.

8、一种无线发射器，包括作为一个电容器的一个振荡源、一个初级激励电路和一个次级接地和一个高架导体，其外部导电边界彼此接近，并且基本上如所描述的那样布置在大曲率半径的表面中。

9. In apparatus for the transmission of electrical energy without wires an elevated conductor or antenna having its outer high potential conducting or capacity elements arranged in proximity to each other and in surfaces of large radii of curvature so as to overcome the effect of the small radius of curvature of the individual elements and leakage of the charge, as set forth.

9、在用于无电线传输电能的装置中，一个高架导体或天线具有其外部高电位导电或电容组件，这些组件彼此靠近地布置在大曲率半径的表面中，以便克服单个组件的小曲率半径和电荷泄漏的影响，如上所述。

10. A grounded resonant transmitting circuit having its outer conducting boundaries arranged in surfaces of large radii of curvature in combination with an elevated terminal of great surface supported at points of low electric density, substantially as described.

10、一种接地谐振发射电路，其外部导电边界设置在大曲率半径的表面上，并与支撑在低电

密度点上的大表面的高架终端相结合，基本上如所述。

NIKOLA TESLA.

尼古拉·特斯拉

Witnesses:

M. LAWSON DYER,

RICHARD DONOVAN.

见证人:

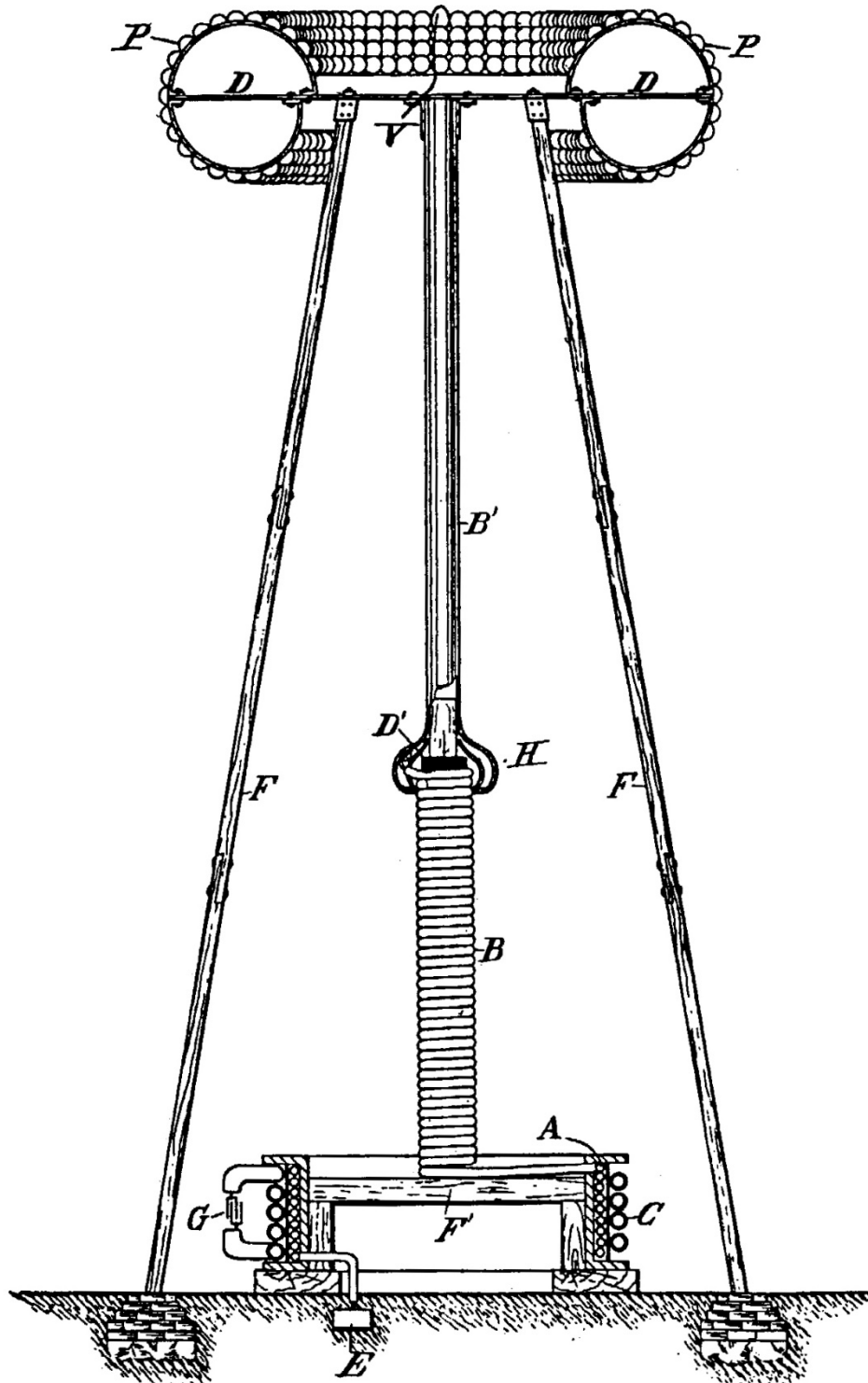
M.劳森·戴尔、理查德·多诺万。

N. TESLA.

APPARATUS FOR TRANSMITTING ELECTRICAL ENERGY.
APPLICATION FILED JAN. 18, 1902. RENEWED MAY 4, 1907.

1,119,732.

Patented Dec. 1, 1914.



WITNESSES:

M. Lawson Dyer
Benjamin Miller.

Nikola Tesla, INVENTOR,
BY *Kenn. Page & Cooper,*
his ATTORNEYS.

ELECTRICAL TRANSFORMER.

电力变压器

NIKOLA TESLA, OF NEW YORK, N. Y.

纽约州纽约市的尼古拉·特斯拉

SPECIFICATION forming part of Letters Patent No. 593,138, dated November 2, 1897.

Application filed March 20, 1897. Serial No. 628,453. (No model.)

该说明书形成了颁发于 1897 年 11 月 2 日编号为 593,138 的专利证书的一部分。

申请于 1897 年 3 月 20 日提交。序列号 628,453。(没有模型)

To all whom it may concern:

致所有相关人士:

Be it known that I, NIKOLA TESLA, a citizen of the United States, residing at New York, in the county and State of New York, have invented certain new and useful improvements in Electrical Transformers, of which the following is a specification, reference being had to the drawings accompanying and forming a part of the same.

众所周知，我，尼古拉·特斯拉，一个美国公民，居住在纽约州纽约郡纽约市，电力变压器方面已经发明了某些新的和有用的改进，以下是该发明一个说明书，必须参考随附的图纸，它已形成该说明书的一部分。

The present application is based upon an apparatus which I have devised and employed for the purpose of developing electrical currents of high potential, which transformers or induction-coils constructed on the principles heretofore followed in the manufacture of such instruments are wholly incapable of producing or practically utilizing, at least without serious liability of the destruction of the apparatus itself and danger to persons approaching or handling it.

本申请基于一种装置，该装置是我为了开发高电位电流而设计和使用的，该装置的变压器或感应线圈是根据迄今为止在制造这种装置时所遵循的原理制造的，这种装置完全不能生产或者实际上无法使用，至少不会严重损坏该装置本身，也不会对接近或操作它的人造成危险。

The improvement involves a novel form of transformer or induction-coil and a system for the transmission of electrical energy by means of the same in which the energy of the source is raised to a much higher potential for transmission over the line than has ever been practically employed heretofore, and the apparatus is constructed with reference to the production of such a potential and so as to be not only free from the danger of injury from the destruction of insulation, but safe to handle. To this end I construct an induction-coil or transformer in which the primary and secondary coils are wound or arranged in such manner that the convolutions of the conductor of the latter will be farther removed from the primary as the liability of injury from the effects of potential increases, the terminal or point of highest potential being the most remote, and

so that between adjacent convolutions there shall be the least possible difference of potential.

该项改进包括一种新型的变压器或感应线圈，以及一种用于传输电能的系统，该系统以同样的方式将电源的能量提升到比迄今为止实际使用最高电势还要高，并且该装置是参照这种电势的产生而构造的，从而不仅没有绝缘破坏的伤害危险，而且操作安全。为此，我构造了一个感应线圈或变压器，其中初级线圈和次级线圈以这样的方式缠绕或布置，使得后者的导体的匝圈由于电势增加效应带来的可能的伤害而远离初级线圈，终端或者电势最高点是最远的，以便在相邻的匝圈之间，可能的电位差为最小。

The type of coil in which the last-named features are present is the flat spiral, and this form I generally employ, winding the primary on the outside of the secondary and taking of the current from the latter at the center or inner end of the spiral. I may depart from or vary this form, however, in the particulars herein after specified.

最后提到的线圈类型的特征是扁平螺旋型，我通常采用这种形式，将初级线圈缠绕在次级线圈的外侧，并从次级线圈在螺旋的中心或内终端获取电流。但是，我可以在说明此处的细节后更改这种形式。

In constructing my improved transformers I employ a length of secondary which is approximately one quarter of the wave length of the electrical disturbance in the circuit including the secondary coil, based on the velocity of propagation of electrical disturbances through such circuit, or, in general, of such length that the potential at the terminal of the secondary which is the more remote from the primary shall be at its maximum. In using these coils I connect one end of the secondary, or that in proximity to the primary, to earth, and in order to more effectually provide against injury to persons or to the apparatus I also connect it with the primary.

在构造我的改进型变压器时，我用的导线长度参考了次级线圈中的波长，它大约是包括次级线圈在内的电路中的电扰动波长的四分之一，这是基于电扰动通过这种电路的传播速度，或者，一般来说，该长度使得远离初级线圈的次级线圈的终端的电位将达到最大值。在使用这些线圈时，我将次级线圈的一端或附近的初级线圈的一端接地，为了更有效地防止人身伤害或设备伤害，我还将次级线圈的一端与初级线圈相连。

In the accompanying drawings, Fig 1 is a diagram illustrating the plan of winding and connection which I employ in constructing my improved coils and the manner of using them for the transmission of energy over long distances. Fig. 2 is a side elevation, and Fig. 3 a side elevation and part section, of modified forms of induction-coil made in accordance with my invention.

在附图中，图 1 是一个示意图，展示了我在构造我的改进型线圈时所采用的绕组和连接的平面图，以及使用它们进行长距离能量传输的方式。根据我的发明制造的感应线圈的改进形式，图 2 是一个侧视图，图 3 是的一个侧视图和部分截面图。

A designates a core, which may be magnetic when so desired.

A 指定一个核芯，当需要的时候可以选择磁性核芯。

B is the secondary coil, wound upon said core in generally spiral form.

B 是次级线圈，缠绕在所述核芯上，通常呈螺旋形。

C is the primary, which is wound around in proximity to the secondary. One terminal of the latter will be at the center of the spiral coil, and from this the current is taken to line or for other purposes. The other terminal of the secondary is connected to earth, and preferably also to the primary.

C 是初级线圈，它缠绕在次级线圈附近。后者的一个终端将位于螺旋线圈的中心，并且电流从这里被引出或用于其他用途。次级线圈的另一端接地，最好能接到初级线圈上。

When two coils are used in a transmission system in which the currents are raised to a high potential and then reconverted to a lower potential, the receiving-transformer will be constructed and connected in the same manner as the first—that is to say, the inner or center end of what corresponds to the secondary of the first will be connected to line and the other end to earth and to the local circuit or that which corresponds to the primary of the first. In such case also the line-wire should be supported in such manner as to avoid loss by the current jumping from line to objects in its vicinity and in contact with earth—as, for example, by means of long insulators, mounted, preferably, on metal poles, so that in case of leakage from the line it will pass harmlessly to earth. In Fig.1, where such a system is illustrated, a dynamo G is conveniently represented as supplying the primary of the sending or “step-up” transformer, and lamps H and motors K are shown as connected with the corresponding circuit of the receiving or “step-down” transformer.

当在一个传输系统中使用两个线圈时，其中的电流被升高到一个高电位，然后再转换到一个较低的电位，接收变压器将以与传输变压器相同的方式构造和连接，也就是说，等于是传输变压器的次级的较内或者中心的终端被连接到线路上，另一终端接地并连接到本地电路或者连接到等于是传输变压器的初级的电路在这种情况下，线路导线也应该以这样的方式支撑，以避免电流从线路跳到其附近的物体以及与地面接触所造成的损失——例如，通过安装在金属杆上的长绝缘体上，以便在线路泄漏的情况下，它将无害地传导到地面。在图 1 中，展示了这样的系统，一个发电机 G 方便地被表示为发送变压器或“升压”变压器的初级供电，灯 H 和电动机 K 被表示为与接收变压器或“降压”变压器的相应电路连接。

Instead of winding the coils in the form of a flat spiral the secondary may be wound on support in the shape of a frustum of a cone and the primary wound around its base, as shown in Fig.2. In practice for apparatus designed for ordinary usage the coil is preferably constructed on the plan illustrated in Fig.3. In this figure L L are spools of insulating material upon which the secondary is wound—in the present case, however, in two sections, so as to constitute really two secondaries. The primary C is a spirally-wound flat strip surrounding both secondaries B.

如图 2 所示，次级线圈可以缠绕在平截头圆锥体形状的支撑物上，而不是以扁平螺旋的形式缠绕线圈，初级线圈缠绕在它的底部。实际上，对于为普通用途设计的设备，线圈最好地在图 3 所示的平面上构建。在该图中，LL 是绝缘材料的线轴，次级线圈缠绕在该线轴上，然而，在本例中，是缠绕在两个部分上，从而实际上构成两个次级线圈。初级线圈 C 是一个螺旋缠绕的扁平带，围绕着两个次级线圈 B。

The inner terminals of the secondaries are led out through tubes of insulating material M, while the other or outside terminals are connected with the primary.

次级线圈的较内终端通过绝缘材料管 M 引出，而另一终端或外终端与初级线圈连接。

The length of the secondary coil B or of each secondary coil when two are used, as in Fig.3, is, as before stated, approximately one-quarter of the wave length of the electrical disturbance in the secondary circuit, based on the velocity of propagation of the electrical disturbance through the coil itself and the circuit with which it is designed to be used-that is to say, if the rate at which a current traverses the circuit, including the coil, be one hundred and eighty-five thousand miles per second, then a frequency of nine hundred and twenty-five per second would maintain nine hundred and twenty-five stationary waves in a circuit one hundred and eighty-five thousand miles long, and each wave length would be two hundred miles in length. For such a frequency I should use a secondary fifty miles in length, so that at one terminal the potential would be zero and at the other maximum.

如图 3 所示，当使用两个次级线圈时，次级线圈 B 或每个次级线圈的长度大约是次级电路中电扰动波长的四分之一，这是基于电扰动通过线圈本身及其设计使用的电路的传播速度，也就是说，如果电流穿过包括线圈在内的电路的速度是每秒 185,000 英里，那么每秒 925 的频率将在 185,000 英里长的电路中维持 925 个静态波，每个波长将有 200 英里长。对于这样一个频率，我应该使用长度为 50 英里的次级线圈，这样在一个终端的电位为零，而另一个终端的电位为最大值。

Coils of the character herein described have several important advantages. As the potential increases with the number of turns the difference of potential between adjacent turns is comparatively small, and hence a very high potential, impracticable with ordinary coils, may be successfully maintained.

这里描述的这种特征的线圈具有几个重要的优点。由于电位随着匝数增加而增加，相邻匝圈之间的电势差相对较小，因此，可以成功地保持非常高的电位，但是普通线圈无法实现。

As the secondary is electrically connected with the primary the latter will be at substantially the same potential as the adjacent portions of the secondary, so that there will be no tendency for sparks to jump from one to the other and destroy the insulation. Moreover, as both primary and secondary are grounded and the line-terminal of the coil carried and protected to a point remote from the apparatus the danger of a discharge through the body of a person handling or approaching the apparatus is reduced to a minimum.

由于次级线圈与初级线圈电连接，初级线圈与次级线圈的相邻部分将处于基本相同的电位，因此不会有火花从一部分跳到另一个部分并破坏绝缘的倾向。此外，由于初级和次级都接地，并且线圈的线路终端被搬运到远离设备的地点并被保护起来，所以通过操作或接近该设备的人的身体的放电的危险被降低到最低。

I am aware that an induction-coil in the form of a flat spiral is not in itself new, and this I do not claim; but what I claim as my invention is-

我知道扁平螺旋形式的感应线圈本身并不是新的，这一点我不主张；但我主张我的发明是：

1. A transformer for developing or converting currents of high potential, comprising a primary and secondary coil, one terminal of the secondary being electrically connected with the primary, and with earth when the transformer is in use, as set forth.

1、一种用于产生或转换高电位电流的变压器，包括一个初级线圈和一个次级线圈，次级线圈的一个终端与初级线圈电连接，并且当变压器使用时该终端与接地连接，如前所述。

2. A transformer for developing or converting currents of high potential, comprising a primary and secondary wound in the form of a flat spiral, the end of the secondary adjacent to the primary being electrically connected therewith and with earth when the transformer is in use, as set forth.

2、一种用于产生或转换高电位电流的变压器，包括一个初级线圈和一个扁平螺旋形式的次级线圈，次级线圈的与初级线圈相邻的终端与初级线圈电连接，并在变压器使用时与接地连接，如前所述。

3. A transformer for developing or converting currents of high potential comprising a primary and secondary wound in the form of a spiral, the secondary being inside of, and surrounded by, the convolutions of the primary and having its adjacent terminal electrically connected therewith and with earth when the transformer is in use, as set forth.

3、一种用于产生或转换高电位电流的变压器，包括一个初级和一个以螺旋形式绕制的次级，次级位于初级的匝圈内部并被初级的匝圈包围，当变压器使用时，初级和次级相邻的终端电连接并接地，如前所述。

4. In a system for the conversion and transmission of electrical energy, the combination of two transformers, one for raising, the other for lowering, the potential of the currents, the said transformers having one terminal of the longer or fine-wire coils connected to line, and the other terminal adjacent to the shorter coils electrically connected therewith and to the earth, as to forth.

4、在一个转换和传输电能的系统中，两个变压器的组合，一个用于升高电流的电位，另一个用于降低电流的电位，所述变压器具有连接到线路上的较长或较细导线线圈的一个终端，与较短线圈相邻的另一个终端电连接并接地，如前所述。

NIKOLA TESLA

尼古拉·特斯拉

Witnesses:

M. LAWSON DYER,

G. W. MARTLING.

见证人：

M.劳森·代尔、G.W.马林。

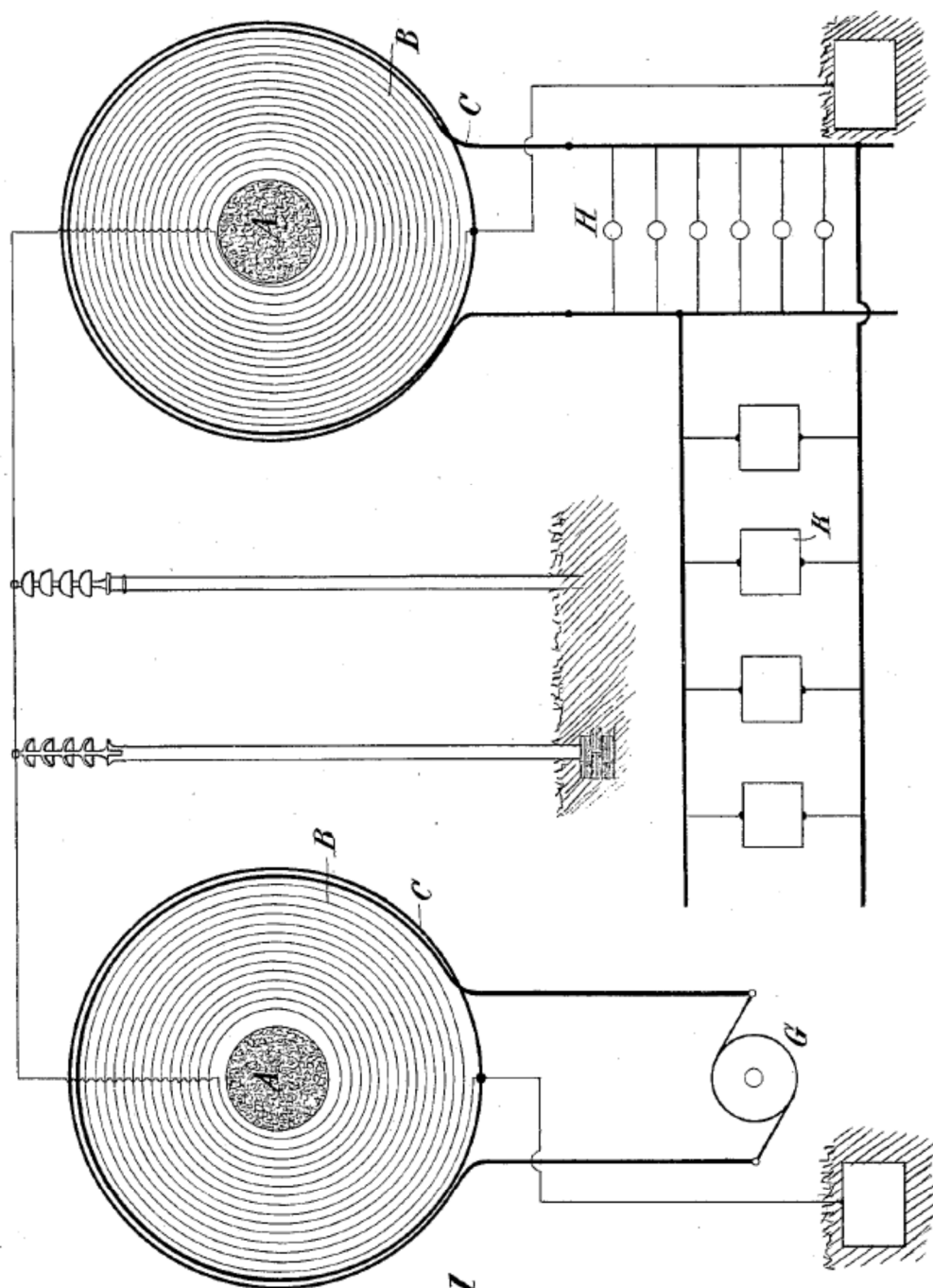
(No Model.)

2 Sheets—Sheet 1.

N. TESLA.
ELECTRICAL TRANSFORMER.

No. 593,138.

Patented Nov. 2, 1897.



WITNESSES

G. B. Lewis.

Edwin B. Hopkinson.

Fig. 1

INVENTOR

Nikola Tesla

BY

Ken. Curtis Age.

ATTORNEY

(No Model.)

2 Sheets—Sheet 2.

N. TESLA.
ELECTRICAL TRANSFORMER.

No. 593,138.

Patented Nov. 2, 1897.

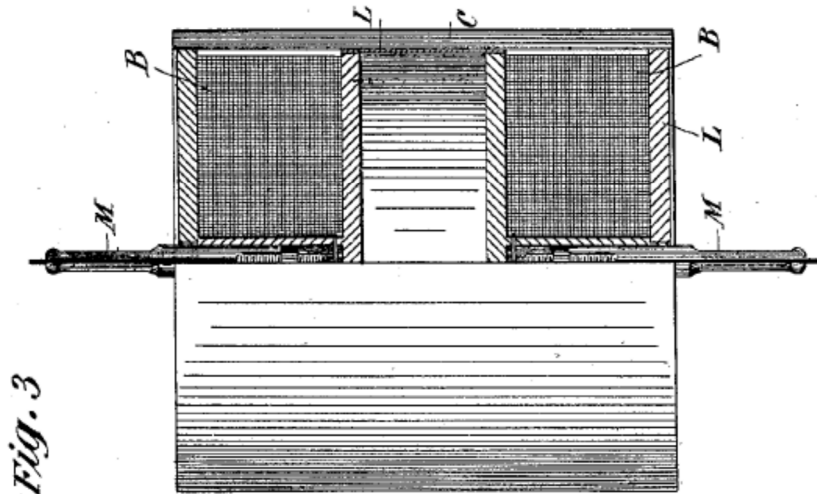


Fig. 3

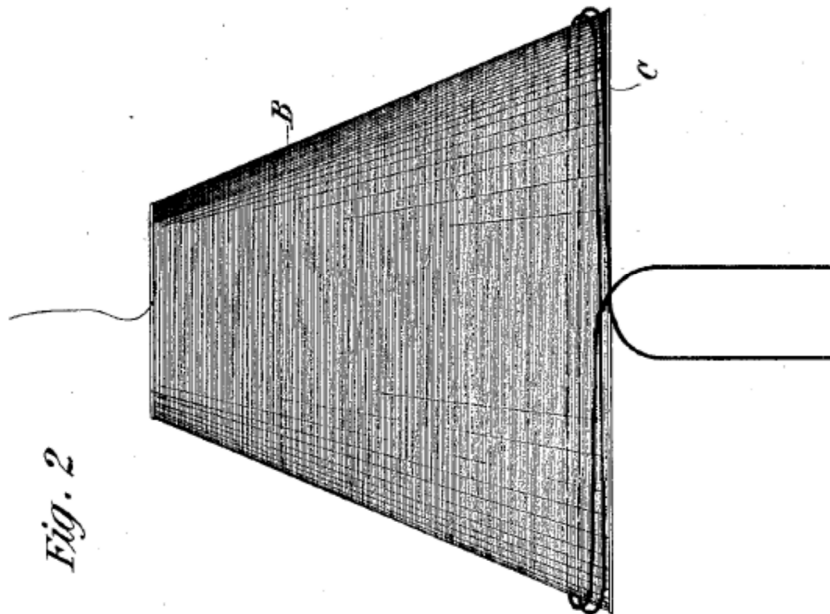


Fig. 2

WITNESSES

G. B. Loria.

Edwin B. Hopkinson.

INVENTOR

Nikola Tesla

BY

Kerr, Curtis & Age

ATTORNEYS.

METHOD OF AND APPARATUS FOR CONTROLLING MECHANISM OF MOVING VESSELS OR VEHICLES. 用于移动船只或车辆的控制机制的工具

NIKOLA TESLA, OF NEW YORK, N. Y.

纽约州纽约市的尼古拉·特斯拉

SPECIFICATION forming part of Letters Patent No. 613,809, dated November 8, 1898.

Application filed July 1, 1898. Serial No. 684,934. (No model.)

该说明书形成了颁发于 1898 年 11 月 8 日的专利证书 613,809 的一部分。

申请于 1898 年 7 月 1 日提交，序列号为 684,934。(无模型。)

To all whom it may concern:

致所有有关人士:

Be it known that I, NIKOLA TESLA, a citizen of the United States, residing at New York, in the county and State of New York, have invented certain new and useful improvements in methods of and apparatus for controlling from a distance the operation of the propelling-engines, the steering apparatus, and other mechanism carried by moving bodies or floating vessels, of which the following is a specification, reference being had to the drawings accompanying and forming a part of the same.

众所周知，我，尼古拉·特斯拉，美国公民，居住在纽约州纽约郡纽约市，发明了某些新的和有用的改进方法和装置，用于从远处控制由运动物体或浮动船只承载的推进发动机、操舵装置和其它机械装置的操作，以下是该发明的一个说明书，必须参考随附的图纸，它已形成该说明书的一部分。

The problem for which the invention forming the subject of my present application affords a complete and practicable solution is that of controlling from a given point the operation of the propelling-engines, the steering apparatus, and other mechanism carried by a moving object, such as a boat or any floating vessel, whereby the movements and course of such body or vessel may be directed and controlled from a distance and any device carried by the same brought into action at any desired time. So far as I am aware the only attempts to solve this problem which have heretofore met with any measure of success have been made in connection with a certain class of vessels the machinery of which was governed by electric currents conveyed to the controlling apparatus through a flexible conductor; but this system is subject to such obvious limitations as are imposed by the length, weight, and strength of the conductor which can be practically used, by the difficulty of maintaining with safety a high speed of the vessel or changing the direction of movement of the same with the desired rapidity, by the necessity for effecting the control from a point which is practically fixed, and by many well-understood drawbacks inseparably connected with such a system. The plan which I have perfected involves none of these objections, for

I am enabled by the use of my invention to employ any means of propulsion, to impart to the moving body or vessel the highest possible speed, to control the operation of its machinery and to direct its movements from either a fixed point or from a body moving and changing its direction however rapidly, and to maintain this control over great distances without any artificial connections between the vessel and the apparatus governing its movements and without such restrictions as these must necessarily impose.

构成本申请主题的本发明提供了一种完整且可行的解决方案，即从给定点控制由运动物体(例如船或任何浮动船只)承载的推进发动机、操舵装置和的其它机械装置的操作，由此可以从远处引导和控制这种物体或船只的运动和路线，并且由该物体或船只承载的任何装置可以在任何预期的时间起作用。据我所知，迄今为止解决这一问题的唯一尝试已经取得了一定程度的成功，这种尝试与某一类船只有关，这些船只的机械由通过柔性导体传送到控制装置的电流控制；但是这种系统受到这样明显的限制，如实际使用的导体的长度、重量和强度，难以安全地保持船舶的高速或以期望的速度改变船舶的运动方向，需要从实际上固定的点进行控制，以及与这种系统密不可分的许多众所周知的缺点。我所完善的方案不涉及这些缺陷，因为我通过使用我的发明使我能够采用任何推进工具，赋予运动的物体或船只最高可能的速度，控制其机械的操作，并从一个固定点或从移动和改变方向的物体上指挥物体或船只的运动，无论它的速度有多快，并在很远的距离上保持这种控制，而无需在船只和控制其运动的装置之间建立任何人工连接，也没有这些必须施加的限制。

In a broad sense, then, my invention differs from all of those systems which provide for the control of the mechanism carried by a moving object and governing its motion in that I require no intermediate wires, cables, or other form of electrical or mechanical connection with the object save the natural media in space. I accomplish, nevertheless, similar results and in a much more practicable manner by producing waves, impulses, or radiations which are received through the earth, water, or atmosphere by suitable apparatus on the moving body and cause the desired actions so long as the body remains within the active region or effective range of such currents, waves, impulses, or radiations.

因此，从广义上讲，我的发明不同于所有那些向一个移动物体所携带的机械装置提供控制并管理其运动的系统，因为除了空间中的自然介质之外，我不需要与物体的中间电线、电缆或其他形式的电气的或机械的连接。然而，我通过产生波、脉冲或辐射来实现类似的结果，并且以一种更加可行的方式，这些波、脉冲或辐射通过大地、水或大气被移动物体上的适当设备接收，并且只要该物体保持在这种电流、波、脉冲或辐射的活动区域或有效范围内，就引起预期的作用。

The many and difficult requirements of the object here contemplated, involving peculiar means for transmitting to a considerable distance an influence capable of causing in a positive and reliable manner these actions, necessitated the designing of devices and apparatus of a novel kind in order to utilize to the best advantage various facts or results, which, either through my own investigations or those of others, have been rendered practically available.

这里设想的目标的许多的和困难的要求，包括用于将能够以积极和可靠的方式引起这些动作的特殊工具，它们用于将影响传送到一个相当远的距离，需要设计一种新颖的装置和设备，以便最好地利用各种事实或结果，通过我自己的研究或其他人的研究，这些事实或结果实际上已经变得可用。

As to the part of my invention which involves the production of suitable waves or variations and the conveying of the same to a remote receiving apparatus capable of being operated or controlled by their influence, it may be carried out in various ways, which are at the present time more or less understood. For example, I may pass through a conducting-path, preferably enclosing a large area, a rapidly-varying current and by electromagnetic induction of the same affect a circuit carried by the moving body. In this case the action at a given distance will be the stronger the larger the area enclosed by the conductor and the greater the rate of change of the current. If the latter were generated in the ordinary ways, the rate of change, and consequently the distance at which the action would be practically available for the present purpose, would be very small; but by adopting such means as I have devised—that is, either by passing through the conducting-path currents of a specially-designed high-frequency alternator or, better still, those of a strongly-charged condenser—a very high rate of change may be obtained and the effective range of the influence thus extended over a vast area, and by carefully adjusting the circuit on the moving body so as to be in exact electromagnetic synchronism with the primary disturbances this influence may be utilized at great distances.

至于我的发明的一部分，它包括产生合适的波或变化，并将其传送到能够通过它们的影响来操作或控制的远程接收装置，它可以以目前或多或少被理解的各种方式来实现。例如，我可以通过一个导电路径，最好是包围了一个大面积，并具有一个快速变化的电流，并且利用该电流的电磁感应去影响由移动体承载的一个电路。在这种情况下，导体所包围的面积越大，在给定距离上的作用越强，电流的变化速率也越大。如果后者是以普通的方式产生的，那么变化的速率，以及由此产生的对于当前目的而言实际可用的距离，将会非常小；但通过采用我设计的这种工具——也就是说，利用经过专门设计的高频交流发电机的传导路径的电流，或者更好的是，那些强充电电容器——可以获得非常高的变化率，影响的有效范围因此扩展到一个广阔的区域，并通过仔细调整运动体上的电路，以便与主要扰动保持精确的电磁同步，这种影响可以在很远的距离上利用。

Another way to carry out my invention is to direct the currents or discharges of a high-frequency machine or condenser through a circuit one terminal of which is connected directly, or inductively with the ground and the other to a body, preferably of large surface and at an elevation. In this case if the circuit on the moving body be similarly arranged or connected differences of potential on the terminals of the circuit either by conduction or electrostatic induction are produced and the same object is attained. Again, to secure the best action the receiving-circuit should be adjusted so as to be in electromagnetic synchronism with the primary source, as before; but in this instance it will be understood by those skilled in the art that if the number of vibrations per unit of time be the same the circuit should now have a length of conductor only one-half of that used in the former case.

实现我的发明的另一种方式是通过一个电路引导一个高频机器或电容器的电流或放电，该电路的一个终端直接或感应地连接到接地，另一端连接到一个物体，该物体最好具有大的表面并处于高处。在这种情况下，如果移动体上的电路被类似地布置或连接，则通过传导或静电感应就能在电路的终端上产生电势差，并且获得相同的目的。再次，为了确保最佳的动作，接收电路应该调整，以便与首要来源电磁同步，如前所述；但是在这种情况下，本领域的技术人员将会理解，如果每单位时间的振动次数相同，那么现在该电路的导体长度应该仅为前一种情况下所用长度的一半。

Still another way is to pass the currents simply through the ground by connecting both the terminals of

the source of high-frequency currents to earth at different and remote points and to utilize the currents spreading through the ground for affecting a receiving-circuit properly placed and adjusted. Again, in this instance if only one of the terminals of the receiving-circuit be connected to the ground, the other terminal being insulated, the adjustment as to synchronism with the source will require that under otherwise equal conditions the length of wire be half of that which would be used if both the terminals be connected or, generally, if the circuit be in the form of a closed loop or coil. Obviously also in the latter case the relative position of the receiving and transmitting circuits is of importance, whereas if the circuit be of the former kind—that is, open—the relative position of the circuits is, as a rule, of little or no consequence.

还有一种方法是通过将高频电流源的两个终端在不同的远端点接地，使电流简单地通过地面，并利用通过地面传播的电流来影响适当放置和调整的接收电路。同样，在这种情况下，如果接收电路的终端只有一个连接到接地，另一个终端是被绝缘的，与来源同步的调整将要求在其他同等条件下，如果两个终端都被连接，或者通常地，如果电路是闭环或线圈的形式，导线的长度是将要使用的一半。显然，在后一种情况下，接收电路和发射电路的相对位置也是重要的，而如果电路是前一种类型的，即开路电路，那么电路的相对位置通常是无关紧要的。

Finally, I may avail myself, in carrying out my invention, of electrical oscillations which do not follow any particular conducting-path, but propagate in straight lines through space, of rays, waves, pulses, or disturbances of any kind capable of bringing the mechanism of the moving body into action from a distance and at the will of the operator by their effect upon suitable controlling devices.

最后，在实施我的发明时，我可以利用电振荡，它不遵循任何特定的传导路径，而是通过光线、波、脉冲或任何种类的扰动在空间中直线传播，能够通过它们对适合的控制装置的影响，从远处并按照操作者的意愿使运动体的机械装置起作用。

In the following detailed description I shall confine myself to an explanation of that method and apparatus only which I have found to be most practical and effectual; but obviously my invention in its broad features is not limited to the special mode and appliances which I have devised and shall here describe.

在下面的详细描述中，我将只限于解释我发现最实用和有效的方法和设备；但是很明显，我的发明在其广泛的特征方面并不局限于我已经设计的并且将在这里描述的特殊模式和装置。

In any event—that is to say, whichever of the above or similar plans I may adopt—and particularly when the influence exerted from a distance upon the receiving-circuit be too small to directly and reliably affect and actuate the controlling apparatus I employ auxiliary sensitive relays or, generally speaking, means capable of being brought into action by the feeblest influences in order to effect the control of the movements of the distant body with the least possible expenditure of energy and at the greatest practicable distance, thus extending the range and usefulness of my invention.

在任何情况下——也就是说，无论我采用上述的或类似的哪一种方案——特别是当从远处施加在接收电路上的影响太小而不能直接和可靠地影响和启动控制装置时，我采用辅助灵敏继电器，或一般来说，是能够被最弱的影响付诸行动的工具，以便以最少的能量消耗和最大的

可行距离实现对远处物体的运动的控制，从而扩展了我的发明的范围和用途。

A great variety of electrical and other devices more or less suitable for the purpose of detecting and utilizing feeble actions are now well known to scientific men and artisans and need not be all enumerated here. Confining myself merely to the electrical as the most practicable of such means and referring only to those which, while not the most sensitive, are perhaps more readily available from the more general knowledge which exists regarding them, I may state that a contrivance may be used which has long been known and used as a lightning-arrester in connection with telephone-switch boards for operating annunciators and like devices, comprising a battery the poles of which are connected to two conducting-terminals separated by a minute thickness of dielectric. The electromotive force of the battery should be such as to strain the thin dielectric layer very nearly to the point of breaking down in order to increase the sensitiveness. When an electrical disturbance reaches a circuit so arranged and adjusted, additional strain is put upon the insulating-film, which gives way and allows the passage of a current which can be utilized to operate any form of circuit-controlling apparatus.

各种各样的或多或少适合于检测和利用微弱动作的电气装置和其它装置现在已为科学人员和技术人员所熟知，因此无需在此一一列举。将我自己仅限于作为此类电气方法中最实用的工具，并且仅提及那些虽然不是最敏感的，但可能更容易从现有的存在于它们自身中的更普遍的知识里获得的那些方法，我可以说可以使用一种早已为人所知的精密装置，它如同与电话开关板连接的避雷器一样使用，用于操作信号器和类似设备，它包括一个电池，电池的不同电极连接到两个导电终端，这两个终端被一个微小厚度的电介质隔开。电池的电动势应该使薄介电层的应变非常接近击穿点，以便增加灵敏度。当一个电扰动到达如此布置和调整的一个电路时，附加的应变施加在绝缘膜上，绝缘膜让位并允许一个电流通过，该电流可用于操作任何形式的电路控制装置。

Again, another contrivance capable of being utilized in detecting feeble electrical effects consists of two conducting plates or terminals which have, preferably, wires of some length attached to them and are bridged by a mass of minute particles of metal or other conducting material. Normally these particles lying loose do not connect the metal plates; but under the influence of an electrical disturbance produced at a distance, evidently owing to electrostatic attraction, they are pressed firmly against each other, thus establishing a good electrical connection between the two terminals. This change of state may be made use of in a number of ways for the above purpose.

同样，另一个精密装置能够用于侦测微弱的电效应，它由两个导电板或终端组成，最好有一些有一定长度的电线连接到它们，并由金属或其他导电材料制成的大量微小颗粒与之桥接。通常这些松散平躺的颗粒不会连接金属板；但是在一定距离处产生的电扰动的影响下，显然由于静电吸引，它们被紧紧地压在一起，从而在两个终端之间建立了良好的电连接。为了上述目的，可以以多种方式利用这种状态改变。

Still another modified device, which may be said to embody the features of both the former, is obtained by connecting the two conducting plates or terminals above referred to permanently with the poles of a battery which should be of very constant electromotive force. In this arrangement a distant electrical disturbance produces a twofold effect on the conducting particles and insulating-films between them. The former are brought nearer to each other in consequence of the sudden increase of electrostatic attraction, and the latter, owing to this, as well as by being reduced in thickness or in number, are

subjected to a much greater strain, which they are unable to withstand.

可以说体现了前两者特征的另一种改进的装置是通过将上述两个导电板或终端与一个电池的电极永久连接而获得的,该电池应该具有非常恒定的电动势。在这种布置中,远处的电扰动对它们之间的导电微粒和绝缘膜产生双重影响。前者由于静电引力的突然增加而彼此靠近,而后者由于这一点以及由于厚度或数量的减少而受到更大的应变,这是它们无法承受的。

It will be obviously noted from the preceding that whichever of these or similar contrivances be used the sensitiveness and, what is often still more important, the reliability of operation is very materially increased by a close adjustment of the periods of vibration of the transmitting and receiving circuits, and, although such adjustment is in many cases unnecessary for the successful carrying out of my invention, I nevertheless make it a rule to bestow upon this feature the greatest possible care, not only because of the above-mentioned advantages, which are secured by the observance of the most favorable conditions in this respect, but also and chiefly with the object of preventing the receiving-circuit from being affected by waves or disturbances emanating from sources not under the control of the operator.

从前面可以明显地看出,无论使用这些或类似的精密装置中的哪一种,通过对发射电路和接收电路的振动周期进行精密调整,操作的灵敏度以及更重要的是操作的可靠性都大大增加了,尽管这种调整在许多情况下对于成功实施我的发明是不必要的,尽管如此,我还是制定了一项规则,对这个特征给予最大可能的照顾,不仅是因为上述优点,这些优点是通过遵守这方面的最有利的条件来保证的,而且主要是为了防止接收电路受到不受操作者控制的来源发出的波或扰动的影响。

The narrower the range of vibrations which are still capable of perceptibly affecting the receiving-circuit the safer will the latter be against extraneous disturbances. To secure the best result, it is necessary, as is well known to experts, to construct the receiving-circuit or that part of the same in which the vibration chiefly occurs so that it will have the highest possible self-induction and at the same time the least possible resistance. In this manner I have demonstrated the practicability of providing a great number of such receiving-circuits—fifty or a hundred, or more—each of which may be called up or brought into action whenever desired without the others being interfered with. This result makes it possible for one operator to direct simultaneously the movements of a number of bodies as well as to control the action of a number of devices located on the same body, each of which may have a distinct duty to fulfill. In the following description, however, I shall show a still further development in this direction—namely, how, by making use of merely one receiving-circuit, a great variety of devices may be actuated and any number of different functions performed at the will and command of the distant operator.

仍然能够明显影响接收电路的振动范围越窄,接收电路就越不会受到外来扰动所影响。为了获得最好的结果,正如专家们所熟知的,有必要构造接收电路或接收电路中振动主要发生的那一部分,使其具有尽可能高的自感,同时具有尽可能小的电阻。以这种方式,我已经证明了装备大量这样的接收电路的可行性——50 或 100, 或更多——每一个都可以在任何需要的时候调用或启动,而不会干扰其他电路。这一结果使得一个操作者可以同时指挥多个物体的运动,以及控制位于同一物体上的多个装置的动作,每个装置都有一个不同的职责。然而,在下面的描述中,我将展示在这个方向上的更进一步的发展——即,如何通过仅使用一个接收电路,可以在远程操作者的意愿和命令下启动各种各样的设备和执行任何数量的不同功能。

It should be stated in advance in regard to the sensitive devices above mentioned, which may be broadly considered as belonging to one class, inasmuch as the operation of all of them involves the breaking down of a minute thickness of highly-strained dielectric, that it is necessary to make some provision for automatically restoring to the dielectric its original unimpaired insulating qualities in order to enable the device to be used in successive operations. This is usually accomplished by a gentle tapping or vibration of the electrodes or particles or continuous rotation of the same; but in long experience with many forms of these devices I have found that such procedures, while suitable in simple and comparatively unimportant operations, as ordinary signaling, when it is merely required that the succeeding effects produced in the receiving-circuit should differ in regard to their relative duration only, in which case it is of little or no consequence if some of the individual effects be altered or incomplete or even entirely missed, do not yield satisfactory results in many instances, when it may be very important that the effects produced should all be exactly such as desired and that none should fail. To illustrate, let it be supposed that an official directing the movements of a vessel in the manner described should find it necessary to bring into action a special device on the latter or to perform a particular operation, perhaps of vital moment, at an instant's notice and possibly when, by design or accident, the vessel itself or any mark indicating its presence is hidden from his view. In this instance a failure or defective action of any part of the apparatus might have disastrous consequences and such cases in which the sure and timely working of the machinery is of paramount importance may often present themselves in practice, and this consideration has impressed me with the necessity of doing away with the defects in the present devices and procedures and of producing an apparatus which while being sensitive will also be most reliable and positive in its action. In the arrangement hereinafter described these defects are overcome in a most satisfactory manner, enabling thousands of successive operations, in all respects alike, being performed by the controlling apparatus without a single irregularity or miss being recorded. For a better understanding of these and other details of the invention as I now carry them out I would refer to the accompanying drawings, in which—

应该预先说明的是，关于上面提到的敏感器件，它们可以被广泛地认为属于一个类别，因为所有这些器件的操作都涉及高度应变的电介质的微小厚度的击穿，所以有必要采取一些措施来自动地将电介质恢复到其原始的未受损的绝缘质量，以便使该器件能够用于连续的操作中。这通常通过轻轻敲击或振动电极或微粒或者持续旋转电极或微粒来实现；但是在对这些设备的许多形式的长期经验中，我发现，当仅仅要求在接收电路中产生的后续效应仅在它们的相对持续时间方面有所不同时，这种程序虽然适合于简单的和相对不重要的操作，如普通的信号传递，在这种情况下，如果这些单独的效应中的一些被改变或者不完全或完全丢失，这是影响不大或者无关紧要，但是在许多情况下不能产生令人满意的结果，当这可能非常重要，那么所产生的效果应该完全如所期望的那样，并且不应该失败。举例来说，让我们假设一个官员以所描述的方式指挥一艘船只的运动，应该发现有必要在后者上启动的一个特殊装置或执行一个特定的操作，也许是在关键时刻的一瞬间，也可能是由于设计或意外，船只本身或任何表明其存在的标记都隐藏在他的视野之外。在这种情况下，设备的任何部分的故障或有缺陷的作用可能会产生灾难性的后果，在这样的例子中，机器的可靠和及时的工作是至关重要，这可能经常出现在实践中，这种考虑给我留下了深刻的印象，必须消除目前设备和程序中的缺陷，生产一种设备，虽然是敏感的，但它的动作也将是最可靠和最明确的。在下文描述的装置中，这些缺陷以最令人满意的方式被克服，使得成千上万个连续的操作得以实现，在所有方面都是相似的，由控制设备执行，而没有记录到一个不规则或遗漏。为了更好地理解本发明的这些和其他细节，当我现在实施它们时，我将参考附图，其中—

Figure 1 is a plan view of a vessel and mechanism within the same. Fig. 2 is a longitudinal section of the same, showing the interior mechanism in side elevation. Fig. 3 is a plan view, partially diagrammatical, of the vessel, apparatus, and circuit connections of the same. Fig. 4 is a plan view, on an enlarged scale, of a portion of the controlling mechanism. Fig. 5 is an end view of the same. Fig. 6 shows the same mechanism in side elevation. Fig. 7 is a side view of a detail of the mechanism. Fig. 8 is a central sectional view, on a larger scale, of a sensitive device forming part of the receiving-circuit. Fig. 9 is a diagrammatic illustration of the system in its preferred form. Fig. 10 is a view of the various mechanisms employed, but on a larger scale, and leaving out or indicating conventionally certain parts of well-understood character.

图 1 是船只及其内部机械装置的平面图。图 2 是其纵向截面图，以侧视图显示了内部机构。图 3 是船只、设备及其电路连接的部分示意平面图。图 4 是控制机械装置的一部分的放大平面图。图 5 是其端视图。图 6 以侧视图展示了其机械结构。图 7 是该结构的细节的侧视图。图 8 是形成接收电路的一部分的敏感器件的放大的中心截面图。图 9 是该系统首选形式的一个示意图。图 10 是所采用的各种机械结构的一个视图，但是以一个较大的比例，并且按照惯例省略或指示了某些易于理解的部分。

Referring to Figs. 1 and 2, A designates any type of vessel or vehicle which is capable of being propelled and directed, such as a boat, a balloon, or a carriage. It may be designed to carry in a suitable compartment B objects of any kind, according to the nature of the uses to which it is to be applied. The vessel—in this instance a boat—is provided with suitable propelling machinery, which is shown as comprising a screw-propeller C, secured to the shaft of an electromagnetic motor D, which derives its power from storage batteries E E E E. In addition to the propelling engine or motor the boat carries also a small steering-motor F, the shaft of which is extended beyond its bearings and provided with a worm which meshes with a toothed wheel G. This latter is fixed to a sleeve b, freely movable on a vertical rod H, and is rotated in one or the other direction, according to the direction of rotation of the motor F.

参考图 1 和 2，A 表示能够被推进和引导的任何类型的船只或交通工具，例如一艘船、一个气球或一辆马车。根据其应用的使用性质，它可以被设计成在合适的隔间 B 中携带任何种类的物体。船只(在这种情况下是一艘船)配备有合适的推进机械，该推进机械被展示为包括了被固定到一个电磁电动机 D 的轴上的螺旋桨 C，该电磁电动机 D 从蓄电池 E E E E 获得动力。除了推进发动机或电动机之外，船上还装有一个小型操舵电动机 F，其轴延伸到轴承之外，并带有一个与齿轮 G 啮合的蜗杆齿轮 G。齿轮 G 被固定在一个套筒 b 上，可在一个垂直杆 H 上自由移动，并根据电机 F 的旋转方向朝一个方向或另一个方向旋转。

The sleeve b on rod H is in gear through the cog-wheels H' and H'', with a spindle G, mounted in vertical bearings at the stem of the boat and carrying the rudder F'.

杆 H 上的套筒 b 通过嵌齿轮 H' 和 H'' 与一个心轴 G 啮合，心轴 G 被安装在船尾的垂直轴承中，并携带方向舵 F'。

The apparatus by means of which the operation of both the propelling and steering mechanism is controlled involves, primarily, a receiving-circuit, which for reasons before stated is preferably both adjusted and rendered sensitive to the influence of waves or impulses emanating from a remote source,

the adjustment being so that the period of oscillation of the circuit is either the same as that of the source or a harmonic thereof.

用来控制推进和转向机械装置的操作的装置主要包括一个接收电路，由于前面所述的原因，该接收电路最好地被调节并对从远处的来源发出的波或脉冲的影响敏感，这种调节使得该电路的振荡周期与该来源的周期或其谐波的周期相同。

The receiving-circuit proper (diagrammatically shown in Figs. 3 and 10) comprises terminal E', conductor C', a sensitive device A', and a conductor A'', leading to the ground conveniently through a connection to the metal keel B' of the vessel. The terminal E' should present a large conducting-surface and should be supported as high as practicable on a standard D', which is shown as broken in Fig. 2; but such provisions are not always necessary. It is important to insulate very well the conductor C' in whatever manner it be supported.

接收电路本身(在图 3 和 10 中示意性地展示)包括终端 E'、导体 C'、一个敏感装置 A' 和一个导体 A''，通过与船的金属龙骨 B' 的连接方便地通向地面。终端 E' 应该具有一个大的导电表面，并且应该尽可能高地被支撑在直立物体 D' 上，物体 D' 如图 2 中被断开的物体所示；但这些规定并不总是必要的。无论以何种方式支撑导体 C'，都必须使其绝缘良好，这是重要的。

The circuit or path just referred to forms also a part of a local circuit, which latter includes a relay-magnet a and a battery a', the electromotive force of which is, as before explained, so determined that although the dielectric layers in the sensitive device A' are subjected to a great strain, yet normally they withstand the strain and no appreciable current flows through the local circuit; but when an electrical disturbance reaches the circuit the dielectric films are broken down, the resistance of the device A' is suddenly and greatly diminished, and a current traverses the relay-magnet A.

刚刚提到的电路或路径也形成了一个局部电路的一部分，该局部电路包括一个继电器磁体 a 和一个电池 a'，如前面解释的，该局部电路的电动势是这样确定的，即尽管敏感装置 A' 中的介电层受到一个很大的应变，但它们通常能承受该应变，并且没有明显的电流流过该局部电路；但是当电扰动到达电路时，介电膜被击穿，装置 A' 的电阻突然大大减小，一个电流通过继电器-磁体 A。

The particular sensitive device employed is shown in general views and in detail in Figs. 4, 6, 7, and 8. It consists of a metal cylinder c, with insulating-heads c', through which passes a central metallic rod c''. A small quantity of grains d of conducting material, such as an oxidized metal, is placed in the cylinder. A metallic strip d', secured to an insulated post d'', bears against the side of the cylinder c, connecting it with the conductor C', forming one part of the circuit. The central rod c'' is connected to the frame of the instrument and so to the other part of the circuit through the forked metal arm e, the ends of which are fastened with two nuts to the projecting ends of the rod, by which means the cylinder c is supported.

图 4、6、7 和 8 中展示了所采用的特定敏感装置的总体视图和细节。它由一个带有绝缘盖 c' 的金属圆筒 c 组成，中心金属杆 c'' 穿过该圆筒。少量的导电材料颗粒 d，例如一种被氧化的金属，被放置在圆筒中。被固定在被绝缘柱 d'' 上的金属条 d' 倚靠在圆柱体 C 的侧面，将圆柱体 C 与导体 C' 连接起来，形成电路的一部分。中心杆 c'' 通过叉形金属臂 e 连接到装置的

框架，从而连接到该电路的另一部分，叉形金属臂 c 的不同端部用两个螺母紧固到杆的突出端，通过这种工具支撑圆筒 c。

In order to interrupt the flow of battery-current which is started through the action of the sensitive device A', special means are provided, which are as follows: The armature e' of the magnet a, when attracted by the latter, closes a circuit containing a battery b' and magnet f. The armature-lever f' of this magnet is fixed to a rock-shaft f'', to which is secured an anchor-escapement g, which controls the movements of a spindle g', driven by a clock-train K. The spindle g' has fixed to it a disk g'' with four pins b'', so that for each oscillation of the escapement g the spindle g' is turned through one-quarter of a revolution. One of the spindles in the clock-train, as h, is geared so as to make one-half of a revolution for each quarter-revolution of spindle g'. The end of the former spindle extends through the side of the frame and carries an eccentric cylinder h', which passes through a slot in a lever h'', pivoted to the side of the frame. The forked arm c, which supports the cylinder c, is pivoted to the end of eccentric b', and the eccentric and said arm are connected by a spiral spring i. Two pins i' i' extend out from the lever h'', and one of these is always in the path of a projection on arm c. They operate to prevent the turning of cylinder c with the spindle h and the eccentric. It will be evident that a half-revolution of the spindle h will wind up the spring i and at the same time raise or lower the lever h'', and these parts are so arranged that just before the half-revolution of the spindle is completed the pin i', in engagement with projection or stop-pin p, is withdrawn from its path, and the cylinder c, obeying the force of the spring i, is suddenly turned end for end, its motion being checked by the other pin i'. The adjustment relatively to armature f' of magnet f is furthermore so made that the pin i' is withdrawn at the moment when the armature has nearly reached its extreme position in its approach toward the magnet—that is, when the lever l, which carries the armature f', almost touches the lower one of the two stops s s, Fig. 5—which limits its motion in both directions.

为了中断通过敏感设备 A' 的动作而启动的电池电流的流动，提供了如下的特殊装置：磁铁 a 的电枢 e' 被敏感设备 A' 吸引时，闭合包含了电池 b' 和磁铁 f 的电路。该磁铁的衔铁杠杆 f' 被固定在摇动轴 f'' 上，摇动轴 f'' 上被固定有锚式擒纵机械装置 g，装置 g 控制由钟表齿轮系 K 驱动的心轴 g' 的运动。心轴 g' 上固定有一个带有四个销 b'' 的圆盘 g''，因此擒纵机械装置 g 每摆动一次，心轴 g' 都旋转四分之一圈。钟表齿轮系中的心轴中的一个，如 h，是齿轮传动的，心轴 g' 每转四分之一圈，它就转二分之一圈。前一个心轴的端部延伸穿过框架的侧面，并且该心轴带有一个偏心圆筒 h'，该圆筒穿过一个杠杆 h'' 上的一个槽，该杠杆枢接于框架的侧面。支撑圆筒 c 的叉臂 c 枢接于偏心轮 b' 的端部，偏心轮与所述臂通过一个螺旋弹簧 i 连接。两个销 i' i' 从杠杆 h'' 伸出，并且其中一个总是在臂 c 上的一个突起的路径中。它们用于防止圆筒 c 随着心轴 h 和偏心轮转动。很明显，心轴 h 的一半旋转将卷起弹簧 i，同时升高或降低杠杆 h''，并且这些部件布置成使得在心轴的一半旋转即将完成之前，与突起或止动销 p 接合的销 i' 从其路径中退出，并且圆筒 c 屈从弹簧 i 的力，突然两端位置颠倒过来，其运动被另一个销 i' 阻止。此外，相对于磁铁 f 的衔铁 f' 的调整是这样进行的，即当衔铁几乎到达其接近磁铁的极限位置时，也就是说，当承载衔铁 f' 的杠杆 l 几乎接触到两个止动件 s s 中较低的一个止动件时，销 i' 撤回，如图 5 所示，该较低止动件限制了杠杆 l 在两个方向上的运动。

The arrangement just described has been the result of long experimenting with the object of overcoming certain defects in devices of this kind, to which reference has been made before. These defects I have found to be due to many causes, as the unequal size, weight, and shape of the grains, the unequal pressure which results from this and from the manner in which the grains are usually agitated, the lack

of uniformity in the conductivity of the surface of the particles owing to the varying thickness of the superficial oxidized layer, the varying condition of the gas or atmosphere in which the particles are immersed, and to certain deficiencies, well known to experts, of the transmitting apparatus as heretofore employed, which are in a large measure reduced by the use of my improved high-frequency coils. To do away with the defects in the sensitive device, I prepare the particles so that they will be in all respects as nearly alike as possible. They are manufactured by a special tool, insuring their equality in size, weight, and shape, and are then uniformly oxidized by placing them for a given time in an acid solution of predetermined strength. This secures equal conductivity of their surfaces and stops their further deterioration, thus preventing a change in the character of the gas in the space in which they are enclosed. I prefer not to rarefy the atmosphere within the sensitive device, as this has the effect of rendering the former less constant in regard to its dielectric properties, but merely secure an airtight enclosure of the particles and rigorous absence of moisture, which is fatal to satisfactory working.

刚刚描述的布置是长期实验的结果，实验的目的是克服这种类型的装置中的某些缺陷，之前已经参考过这种装置。我发现这些缺陷是由多种原因造成的，如颗粒的大小、重量和形状的不一致，由此产生的压力不一致，颗粒通常被搅动的方式不一致，由于表面氧化层厚度的变化，颗粒浸入的气体或环境条件的变化，以及对于专家来说众所周知的迄今为止所使用的发射装置的某些缺陷，通过使用我的改进的高频线圈，在很大程度上减少了。为了消除敏感设备中的缺陷，我准备的颗粒使它们在各方面尽可能接近。它们由特殊的工具制造，确保它们在大小、重量和形状上的一致，然后通过将它们放置在预定浓度的一种酸溶液中在给定的时间来均匀氧化。这保证了它们的表面具有同等的导电性，并阻止了它们的进一步蜕变，从而防止了封闭它们在空间中的气体的特性变化。我不喜欢将敏感设备中的空气稀薄化，因为这会导致前者的介电特性不那么恒定，但仅仅是为了确保颗粒的一个气密外壳和严格缺乏水分的条件，这对得到满意的效果是至关重要的。

The normal position of the cylinder c is vertical, and when turned in the manner described the grains in it are simply shifted from one end to the other; but inasmuch as they always fall through the same space and are subjected to the same agitation they are brought after each operation of the relay to precisely the same electrical condition and offer the same resistance to the flow of the battery-current until another impulse from afar reaches the receiving-circuit.

圆柱体 c 的正常位置是竖直的，当以所描述的方式转动时，其中的颗粒只是从一端移动到另一端；但由于它们总是穿过相同的空间并受到相同的搅动，所以在继电器的每次操作之后，它们被带到完全相同的电状态，并对电池电流的流动提供相同的电阻，直到来自远处的另一个脉冲到达接收电路。

The relay-magnet a should be of such character as to respond to a very weak current and yet be positive in its action. To insure the retraction of its armature e' after the current has been established through the magnet f and interrupted by the inversion of the sensitive device c, a light rod k is supported in guides on the frame in position to be lifted by an extension k' of the armature-lever l and to raise slightly the armature e. As a feeble current may normally flow through the sensitive device and the relay-magnet a, which would be sufficient to hold though not draw the armature down, it is well to observe this precaution.

继电器磁铁 a 应该具有这样的特性，即能对非常微弱的电流做出反应，但其作用却是积极的。

为了确保在该电流在通过磁体 f 建立并被敏感装置 c 的反向转动中断之后, 衔铁 e' 能够撤回, 一根轻棒 k 被支撑在框架上的导向件中, 处于被衔铁杠杆 l 的延伸部分 k' 提升并稍微提升衔铁 e 的位置。由于一个微弱的电流通常可以流过敏感装置和继电器磁体 a, 这将足以抓住衔铁, 但不会将拉下衔铁, 最好遵守此预防措施。

The operation of the relay-magnet a and the consequent operation of the electromagnet f, as above described, are utilized to control the operation of the propelling-engine and the steering apparatus in the following manner: On the spindle g', which carries the escapement-disk g", Figs. 4 and 6, is a cylinder j of insulating material with a conducting plate or head at each end. From these two heads, respectively, contact plates or segments j' j" extend on diametrically opposite sides of the cylinder. The plate j" is in electrical connection with the frame of the instrument through the head from which it extends, while insulated strips or brushes J J' bear upon the free end or head of the cylinder and the periphery of the same, respectively. Three terminals are thus provided, one always in connection with plate j', the other always in connection with the plate j", and the third adapted to rest on the strips j' and j" in succession or upon the intermediate insulating-spaces, according to the position in which the commutator is brought by the clock-train and the anchor-escapement g.

如上所述, 继电器磁体 a 的操作和随之而来的电磁体 f 的操作被用于以下述方式控制推进发动机和转向装置的操作: 如图 4 和图 6 所示, 在心轴 g' 上携带擒纵盘 g" 的是一个绝缘材料制成的圆筒 j, 其两端均带有导电板或导电头。接触板或接触段 j' j" 分别从这两个导电头在圆柱体的直径上相对侧延伸。板 j" 通过其延伸出的头部与仪器的框架电连接, 而被绝缘的条或电刷 J J' 分别倚靠在圆柱的自由端或头部及其外周上。因此, 提供了三个终端, 一个始终与板 j' 连接, 另一个始终与板 j" 连接, 第三个适合于根据换向器被钟表齿轮系和锚式擒纵机构 g 带到的位置, 连续地放置在条 j' 和 j" 上或者放置在中间绝缘空间上。

K' K", Figs. 1, 3, and 10, are two relay-magnets conveniently placed in the rear of the propelling-engine. One terminal of a battery k" is connected to one end of each of the relay-coils, the opposite terminal to the brush J', and the opposite ends of the relay-coils to the brush J and to the frame of the instrument, respectively. As a consequence of this arrangement either the relay K' or K" will be energized as the brush J' bears upon the plate j' or j", respectively, or both relays will be inactive while the brush J' bears upon an insulating-space between the plates j' and j". While one relay, as K', is energized, its armature closes a circuit through the motor F, which is rotated in a direction to throw the rudder to port. On the other hand, when relay K" is active another circuit through the motor F is closed, which reverses its direction of rotation and shifts the rudder to starboard. These circuits, however, are at the same time utilized for other purposes, and their course is, in part, through apparatus which I shall describe before tracing their course.

图 1、图 3 和图 10 中的 K' K" 是两个继电器磁铁, 方便地安装在推进发动机的后部。电池 k" 的一端连接到每个继电器线圈的一端, 另一端连接到电刷 J', 这些继电器线圈的相对的两端分别连接到电刷 J 和装置的框架。由于这种布置, 当电刷 J' 分别压在板 j' 或 j" 上时, 继电器 K' 或 K" 将被激励, 或者当电刷 J' 压在板 j' 和 j" 之间的绝缘空间上时, 两个继电器都不起作用。当一个继电器(如 K') 通电时, 其衔铁通过电动机 F 闭合一个电路, 电动机 F 沿一个方向旋转, 将方向舵转向左舷。另一方面, 当继电器 K" 被激活时, 通过电动机 F 的另一个电路被闭合, 这反转其旋转方向并将方向舵转向右舷。然而, 这些电路同时也用于其他目的, 它们的航线, 部分是通过装置, 我将在跟踪它们的航向之前描述这些装置。

The fixed rod H carries an insulating disk or head L, Fig. 2, to the under side of which are secured six brushes, 1, 2, 3, 4, 5, and 6, Fig. 3. The sleeve b, which surrounds the rod and is turned by the steering-motor F, carries a disk L', upon the upper face of which are two concentric circles of conducting contact-plates. Brushes 1, 2, 3, and 4 bear upon the inner circle of contacts, while the brushes 5 and 6 bear upon the outer circle of contacts. The outer circle of contacts comprises two long plates 7 and 8 on opposite sides of the disk and a series of shorter plates 9, 10, 11, 12, 13, and 14 in the front and rear. Flexible conductors l' l'' connect the plates 7 and 8 with the terminals of the propelling-motor D, and the poles of the main battery E are connected to the brushes 5 and 6, respectively, so that while the rudder is straight or turned up to a certain angle to either side the current is conveyed through the brushes 5 and 6 and segments 7 and 8 to the propelling-motor D. The steering-motor F is also driven by current taken from the main battery E in the following manner: A conductor 15 from one pole of the battery leads to one of the commutator-brushes, and from the other brush runs a conductor 16 to one of the contacts of each relay K' K''. When one of these relays, as K'', is active, it continues this circuit through a wire 19 through one field-coil or set of coils on the motor F and thence to the brush 1. In a similar manner when the other relay K' is active the circuit is continued from wire 18 through a wire 20, the second or reversing set of field-coils, and to brush 2.

固定杆 H 带有一个绝缘盘或绝缘头 L, 见图 2, 在绝缘盘或绝缘头 L 的下方固定有六个电刷 1、2、3、4、5 和 6, 见图 3。包围杆并由操舵电动机 F 转动的套筒 b 带有一个圆盘 L', 在圆盘 L' 的上表面上有两个导电接触板的同心圆。电刷 1、2、3 和 4 倚靠在触点的内圈上, 而电刷 5 和 6 压在触点的外圈上。触点的外圈包括位于圆盘相对侧的两个长板 7 和 8 以及位于前面和后面的一系列短板 9、10、11、12、13 和 14。柔性导体 l' l'' 将板 7 和 8 与推进电动机 D 的终端连接, 主供电电池 E 的电极分别连接到电刷 5 和 6, 从而当方向舵是直的或向任一侧转动一定角度时, 电流通过电刷 5 和 6 以及分段 7 和 8 传送到推进电动机 D 操舵电机 F 也由来自主供电电池 E 的电流以如下方式驱动: 来自电池的一个极的导体 15 连接到换向器电刷中的一个, 而从这些电刷中另一个电刷引出的导体 16 连接到一个每个继电器的触点 K'K''。当这些继电器中的一个, 如 K'', 被激活时, 从导线 19 开始, 通过电动机 F 上的一个励磁线圈或线圈组, 并由此到达电刷 1 的电路被恢复。以类似的方式, 当另一个继电器 K' 被激活时, 从导线 18 开始, 然后通过一个导线 20 和次级或励磁线圈的反转线圈组最后到达电刷 2 的电路被恢复。

Both brushes 1 and 2 at all times when the rudder is not turned more than about forty-five degrees to one side are in contact with a long conducting-plate 21, and one brush in any position of the rudder is always in contact with said plate, and the latter is connected by a flexible conductor 22 with the opposite pole of the main battery. Hence the motor F may always be caused to rotate in one direction whatever may be the position of the rudder, and may be caused to rotate in either direction whenever the position of the rudder is less than a predetermined angle, conveniently forty-five degrees from the center position. In order, however, to prevent the rudder from being turned too far in either direction, the isolated plate 23 is used. Any movement of the rudder beyond a predetermined limit brings this plate under one or the other of the brushes 1 2 and breaks the circuit of motor F, so that the rudder can be driven no farther in that direction, but, as will be understood, the apparatus is in condition to turn the rudder over to the other side. In like manner the circuit of the propelling-motor D is controlled through brushes 5 and 6 and the segments on the outer circle of contacts of head L. If the short segments on either side of the circle are insulated, the motor D will be stopped whenever one of the brushes 5 or 6 passes onto one of them from the larger segments 7 8.

当方向舵向一侧转动不超过大约 45 度时，电刷 1 和 2 总是与长导电板 21 接触，并且在方向舵的任何位置，一个电刷总是与所述板接触，并且后者通过柔性导体 22 与主供电电池的另一电极连接。因此，无论方向舵的位置如何，电动机 F 总是可以沿一个方向旋转，并且每当方向舵的位置小于预定角度时，电动机 F 可以沿任一方向旋转，该预定角度方便地被定为距中心位置 45 度。然而，为了防止方向舵在任一方向上转得太远，使用了隔离板 23。超过一个预定限度的任何方向舵的运动将该板带到电刷 1 和 2 中一个或者另一个的下面，并断开电动机 F 的电路，从而方向舵不能在该方向上被进一步驱动，但是，如同将要理解的，该装置处于将方向舵转向另一侧的状态。以类似的方式，推进电动机 D 的电路通过电刷 5 和 6 以及头部 L 的触点的外圆上的分段来控制。如果圆的任一侧的短分段是绝缘的，每当电刷 5 或 6 中的一个经过较大的分段 7 或 8 中的一个时，电动机 D 将停止。

It is important to add that on all contact-points where a break occurs provision should be made to overcome the sparking and prevent the oscillation of electrical charges in the circuits, as such sparks and oscillations may affect the sensitive device. It is this consideration chiefly which makes it advisable to use the two relays K' K", which otherwise might be dispensed with. They should be also placed as far as practicable from the sensitive device in order to guard the latter against any action of strong varying currents.

重要的是要补充一点，在发生断路的所有接触点上，应采取措施克服火花并防止电路中的电荷振荡，因为这种火花和振荡可能会影响敏感设备。主要是这种考虑使得使用两个继电器 K' K" 是可取的，否则可能被省去。它们还应尽可能远离敏感装置，以保护后者免受强变化电流的任何影响。

In addition to the mechanism described the vessel may carry any other devices or apparatus as might be required for accomplishing any special object of more or less importance. By way of illustration a small motor m is shown, Figs. 1 and 3, which conveniently serves for a number of purposes. This motor is shown connected in series with the armature of the steering-motor F, so that whenever either one of the circuits of the latter is closed through relays K' K" the motor m is likewise rotated, but in all cases in the same direction. Its rotation is opposed by a spring m', so that in normal operation, owing to the fact that the circuits of motor F are closed but a short time, the lever m", which is fastened to one of the wheels of clockwork M, with which the armature of the motor is geared, will move but a short distance and upon cessation of the current return to a stop P; but if the circuits of the motor F are closed and opened rapidly in succession, which operation leaves the rudder unaffected, then the lever m" is moved to a greater angle, coming in contact with a metal plate n, and finally, if desired, with a post n'. Upon the lever m" coming in contact with plate n the current of the main battery passes either through one or other or both of the lights supported on standards q q, according to the position of brushes 3 and 4 relatively to the insulating-segment 23; but since the head L, carrying the segments, is geared to the rudder the position of the latter is in a general way determined by observing the lights. Both of the lights may be colored, and by flashing them up whenever desired the operator may guide at night the vessel in its course. For such purposes also the standards r r are provided, which should be painted in lively colors, so as to be visible by day at great distances. By opening and closing the circuits of motor F a greater number of times, preferably determined beforehand, the lever m" is brought in contact with post n', thus closing the circuit of the main battery through a device o and bringing the latter into action at the moment desired. By similar contrivances or such as will readily suggest themselves to mechanics any number of different devices may be operated.

除了所描述的机械装置之外，该船只还可携带任何其它装置或仪器，以实现任何或多或少重要的特殊目的。作为说明，图 1 和图 3 展示了小型电动机 m ，其方便地用于多种目的。该电动机被展示与操舵电动机 F 的电枢串联连接，从而每当操舵电动机 F 的任一个电路通过继电器 $K'K''$ 闭合时，电动机 m 同样旋转，但是在所有情况下都以相同的方向旋转。它的旋转受到弹簧 m' 的抵抗，因此在正常操作中，由于电机 F 的电路闭合时间很短，固定在发条装置 M 的轮子中的一个轮子上的杠杆 m'' 将移动很短的距离，并且在电流停止时返回到停止点 P ；但是如果电动机 F 的电路连续快速地闭合和断开，这种操作不会影响方向舵，那么杠杆 m'' 被移动到更大的角度，与一个金属板 n 接触，并且最后，如果需要，与一个柱 n' 接触。当杠杆 m'' 与板 n 接触时，根据电刷 3 和 4 相对于绝缘分段 23 的位置，主供电电池的电流流经被支撑在立柱 $q q$ 上的一个或另一个或两个灯；但是，由于带有分段的头部 L 与舵相啮合，所以舵的位置通常通过观察灯来确定。这两种灯都可以是彩色的，只要需要，操作者就可以在夜间通过闪烁灯光来引导船只。为此目的，还装配了立柱 $r r$ ，这些立柱应涂上鲜艳的颜色，以便白天在很远的地方都能看见。通过断开和闭合电动机 F 的电路更多次，最好事先确定，杠杆 m'' 与接线柱 n' 接触，从而通过装置 o 闭合主供电电池的电路，并使装置 o 在期望的时刻起作用。通过类似的精密装置或这样的装置将很容易向机械师建议任何数量的不同的可以操作的装置。

Referring now to Fig. 9, which illustrates diagrammatically the system as practiced when directing the movements of a boat, in this figure S designates any source of electrical disturbance or oscillations the generation of which is controlled by a suitable switch contained in box T . The handle of the switch is movable in one direction only and stops on four points $t' t' u u'$, so that as the handle passes from stop to stop oscillations are produced by the source during a very short time interval. There are thus produced four disturbances during one revolution and the receiving-circuit is affected four times; but it will be understood from the foregoing description of the controlling devices on the vessel that the rudder will be moved twice, once to right and once to left. Now I preferably place the handle of the switch so that when it is arrested on points $t' t'$ —that is, to the right or left of the operator—he is reminded that the vessel is being deflected to the right or left from its course, by which means the control is facilitated. The normal positions of the handle are therefore at $u u'$ when the rudder is not acted upon, and it remains on the points $u u'$ only so long as necessary. Since, as before stated, the working of the apparatus is very sure, the operator is enabled to perform any such operations as provision is made for without even seeing the vessel.

现在参照图 9，该图展示了当指挥一艘船的运动时所实施的系统，在该图中， S 表示任何电扰动或振荡的来源，电扰动或振荡的产生由容纳在盒 T 中的合适开关所控制。开关的手柄只能在一个方向上移动，并在四个点 $t' t' u u'$ 上停止，因此当手柄从一个停止点移动到另一个停止点时，振荡源在很短的时间间隔期间产生振荡。因此，在一次旋转中产生四次扰动，接收电路被影响四次；但是从前面对船上控制装置的描述可以理解，方向舵将移动两次，一次向右，一次向左。现在，我更喜欢这样放置开关的手柄，就是当它停在点 $t' t'$ 上时，也就是说，在操作者的右边或左边，他被提醒船只正偏离其航线，在向右或向左偏转，通过这种方式便于控制。因此，当方向舵未被操纵时，手柄的正常位置在 $u u'$ 处，只要有必要，手柄就保持在 $u u'$ 点上。由于如前所述，该设备的工作非常可靠，因此操作员能够执行任何规定的操作，甚至无需看到船只。

The manner of using the apparatus and the operation of the several instrumentalities comprising the same is in detail as follows: Normally the plate L' is turned so that brush 2 rests upon the insulated

segment 23 and brush 6 upon one of the insulated short segments in the rear of the circle. Under these conditions the rudder will be turned to starboard and the circuit of motor D interrupted between brushes 5 and 6. At the same time only one of the circuits of motor F—that controlled by relay K'—is capable of being closed, since brush 2, which connects with the other, is out of contact with the long segment 21. Assuming now that it is desired to start the vessel and direct it to a given point, the handle T is turned from its normal position on point u' to the point t on the switch-box. This sends out an electrical disturbance, which, passing through the receiving-circuit on the vessel, affects the sensitive device A' and starts the flow of current through the local-circuit, including said device, the relay a, and the battery a'. This, as has been previously explained, turns the cylinder j and causes the brush J' to pass from insulation onto the contact j'. The battery k" is thus closed through relay K", and the latter closes that circuit of the motor F which, starting from plate 22, which is permanently connected with one pole of the main battery, is completed through the brush 1, the field of motor F, wire 19, the armature of relay K", wire 16, the motor m, the brushes and commutator of motor F, and wire 15 to the opposite terminal of the battery E. Motor F is thus set in operation to shift the rudder to port; but the movement of plate L' which follows brings the brush 6 back onto segment 8 and closes the circuit of the propelling-motor which starts the vessel. The motor F is permitted to run until the rudder has been turned sufficiently to steer the vessel in the desired direction, when the handle T is turned to the point u. This produces another action of the relay a and brush J' is shifted onto insulation and both relays K' and K" are inactive. The rudder remains in the position to which it has been shifted by the motor F. If it be then desired to shift it to starboard, or in the opposite direction to that in which it was last moved, the handle T is simply turned to point t' and allowed to remain there until the motor F, which is now operated by relay K', the circuit of which is closed by strip J' coming into contact with plate j", has done its work. The movement of handle T to the next point throws out both relays K' and K", and the next movement causes a shifting of the rudder to port, and so on. Suppose, however, that after the rudder has been set at any angle to its middle position it be desired to shift it still farther in the same direction. In such case the handle is moved quickly over two points, so that the circuit which would move the rudder in the opposite direction is closed for too short a time interval to produce an appreciable effect and is allowed to rest on the third point until the rudder is shifted to the desired position, when the handle is moved to the next point, which again throws out both relays K' and K". It will be understood that if the handle be held for a sufficiently long time upon either point t or t' the motor F will simply turn the plate L' in one direction or the other until the circuits of motors D and F are broken. It is furthermore evident that one relay K' or K" will always be operative to start the motor F.

使用该设备的方式和包括该设备的几个工具的操作详细如下：正常情况下，板 L' 被转动使电刷 2 倚靠在绝缘段 23 上，电刷 6 靠在圆圈后面的一个短绝缘分段上。在这种情况下，方向舵将转向右舷，电动机 D 的电路在电刷 5 和 6 之间中断。同时，电动机 F 的不同电路中只有一个——由继电器 K' 控制——能够闭合，因为与另一个电路连接的电刷 2 不与长分段 21 接触。现在假设希望启动船舶并将其导向指定地点，手柄 T 从其在点 u' 上的正常位置转动到开关盒上的点 T。这里发出一个电扰动，该电扰动通过船上的接收电路，影响敏感设备 A'，并且电流开始通过包括所述设备、继电器 a 和电池 a' 的局部电路。如前所述，这使圆柱 j 转动，并使电刷 J' 从绝缘件转到触点 j' 上。因此，电池 k" 通过继电器 K" 闭合，并且后者闭合电动机 F 的电路，该电路从与主供电电池的一个电极永久连接的板 22 开始，通过电刷 1、电动机 F 的磁场、导线 19、继电器 K" 的衔铁、导线 16、电动机 m、电动机 F 的电刷和换向器以及导线 15，一直到电池 E 的相对终端。因此，电机 F 开始运转，将方向舵转向左舷；但是板 L' 随后的运动将刷子 6 带回分段 8 上，并闭合启动船只的推进电动机的电路。当手柄 T 被转

动到点 u 时，电动机 F 被允许运转，直到方向舵已经被充分转动以将船转向期望的方向。这产生了继电器 a 的另一个动作，电刷 J' 移动到绝缘上，继电器 K' 和 K'' 都没有激活。方向舵保持在它被电动机 f 移动到的位置。如果随后希望将它移向右舷，或者移向与它最后移动的方向相反的方向，把手 T 简单地转动到点 t' 并保持在那里，直到电动机 F 完成它的工作，电动机 F 现在由继电器 K' 操作，继电器 K' 的电路由与板 j'' 接触的条 J' 闭合。手柄 T 向下一点的移动断开了继电器 K' 和 K''，下一次移动导致方向舵向左舷移动，以此类推。然而，假设在方向舵以任意角度设置到其中间位置后，需要在同一方向上进一步移动方向舵。在这种情况下，手柄在两个点上方快速移动，使得将使方向舵向沿着相反方向移动的电路闭合的时间间隔太短而不能产生明显的效果，并且被允许停留在第三个点上，直到方向舵移动到期望的位置，当手柄移动到下一个点时，这再次断开继电器 K' 和 K''。可以理解，如果手柄在 t 点或 t' 点保持足够长的时间，电动机 F 将简单地在一个方向或另一个方向转动板 L'，直到电动机 D 的电路和 F 的电路被断开。此外，很明显，一个继电器 K' 或 K'' 将总是可操作地启动电动机 F。

As previously explained, the longest period of operation of which the motor F is capable under ordinary conditions of use does not permit the motor m to shift the arm m' into contact with the plate n; but if the handle T be turned with a certain rapidity a series of current impulses will be directed through motor m; but as these tends to rotate the motor F in opposite directions they do not sensibly affect the latter, but act to rotate the motor m against the force of the coiled spring.

如前所述，电动机 F 在正常使用条件下所能运行的最长时间不允许电动机 m 移动臂 m' 与板 n 接触；但是如果把手 T 以一定的速度转动，一连串的电脉冲将通过电动机 m；但是由于这些趋向于在相反的方向上转动电动机 F，它们不会明显地影响后者，而是抵抗螺旋弹簧的力来转动电动机 m。

The invention which I have described will prove useful in many ways. Vessels or vehicles of any kind may be used, as life, dispatch, or pilot boats or the like, or for carrying letters, packages, provisions, instruments, objects, or materials of any description, for establishing communication with inaccessible regions and exploring the conditions existing in the same, for killing or capturing whales or other animals of the sea, and for many other scientific, engineering, or commercial purposes; but the greatest value of my invention will result from its effect upon warfare and armaments, for by reason of its certain and unlimited destructiveness it will tend to bring about and maintain permanent peace among nations.

我所描述的发明将在许多方面被证明是有用的。任何种类的船舶或交通工具可用作救生、派遣或领航艇等，或用于运载信件、包裹、供应品、仪器、物体或任何种类的材料，用于与交通不便的地区建立联系并考察该地区的状况，用于捕杀或捕获鲸鱼或其他海洋动物，以及用于许多其他科学、工程或商业目的；但是我的发明的最大价值将来自它对战争和军备的影响，因为由于它的确定的和无限的破坏性，它将倾向于带来和维持国家间的永久和平。

Having now described my invention, what I claim is—

现在描述了我的发明，我主张的是—

1. The improvement in the art of controlling the movements and operation of a vessel or vehicle herein described, which consist in producing waves or disturbances which are conveyed to the vessel by the

natural media, actuating thereby suitable apparatus on the vessel and effecting the control of the propelling-engine, the steering and other mechanism by the operation of the said apparatus, as set forth.

1、在此所述的对控制船只或车辆的运动和操作的技术的改进,这种改进在于产生波或扰动,它们可以通过自然介质传递到船只,从而开动船只上的适合的设备,并通过所述设备的操作实现对推进发动机、转向和其它机械装置的控制,如前所述。

2. The improvement in the art of controlling the movements and operation of a vessel or vehicle, herein described, which consists in establishing a region of waves or disturbances, and actuating by their influence exerted at a distance the devices on such vessel or vehicle, which control the propelling, steering and other mechanism thereon, as set forth.

2、在此所述的对控制船只或交通工具的运动和操作的技术的改进,这种改进在于产生一个波或扰动的区域,并通过这些波或扰动在远处施加的影响来驱动这种船只或交通工具上的装置,这些装置控制推进、转向和其上的其它机械装置,如前所述。

3. The improvement in the art of controlling the movements and operation of a vessel or vehicle, herein described, which consists in establishing a region of electrical waves or disturbances, and actuating by their influence, exerted at a distance, the devices on said vessel or vehicle, which control the propelling, steering and other mechanism thereon, as set forth.

3、在此所述的对控制船只或交通工具的运动和操作的技术的改进,这种改进在于产生一个电波或电扰动的区域,并通过这些电波或电扰动在远处施加的影响来驱动所述船只或交通工具上的装置,所述装置控制推进、转向和其上的其它机械装置,如前所述。

4. The improvement in the art of controlling the movements and operation of a vessel or vehicle, herein described, which consists in providing on the vessel a circuit controlling the propelling, steering and other mechanism, adjusting or rendering such circuit sensitive to ways or disturbances of a definite character, establishing a region of such waves or disturbances, and rendering by their means the controlling-circuit active or inactive, as set forth.

4、在此所述的对控制船只或车辆的运动和操作的技术的改进,这种改进在于在船只上提供控制推进、转向和其它机械装置的电路,该电路调节或使得这种电路对确定特征的方法或扰动敏感,并建立这种波或扰动的区域,并通过它们的工具使得控制电路激活或不激活,如前所述。

5. The combination with a source of electrical waves or disturbances of a moving vessel or vehicle, and mechanism thereon for propelling, steering or operating the same, and a controlling apparatus adapted to be actuated by the influence of the said waves or disturbances at a distance from the source, as set forth.

5、存在一个组合,它包括一个移动船只或车辆的电波或电扰动的来源、以及在这些交通工具上的用于推进、转向或操作该移动船只或车辆的机械装置、以及适于在距离所述来源一定距离处受所述电波或电扰动的影响而启动的控制设备,如前所述。

6. The combination with a source of electrical waves or disturbances of a moving vessel or vehicle, mechanism for propelling, steering or operating the same, a circuit and means therein for controlling said mechanism, and means for rendering said circuit active or inactive through the influence of the said waves or disturbances exerted at a distance from the source, as set forth.

6、存在一个组合，它包括一个移动船只或车辆的电波或电扰动的来源、用于推进、转向或操作该交通工具的机械装置、在其中用于控制所述机械装置的电路和工具、以及用于通过在离所述来源一定距离处施加的所述电波或电扰动的影响使所述电路起激活或不激活的工具，如前所述。

7. The combination with a source of electrical waves or disturbances and means for starting and stopping the same, of a vessel or vehicle, propelling and steering mechanism carried thereby, a circuit containing or connected with means for controlling the operation of said mechanism and adjusted or rendered sensitive to the waves or disturbances of the source, as set forth.

7、存在一个组合，它包括电波或电扰动的一个来源、用于开启和停止该来源的工具、一个船只或车辆，以及由此承载的推进和转向机械装置、一个电路，它包含了或连接了有助于控制所述机械装置的电路，该电路被调整并对所述来源的波或扰动敏感，如前所述。

8. The combination with a source of electrical waves or disturbances, and means for starting and stopping the operation of the same, of a vessel or vehicle, propelling and steering mechanism carried thereby, local circuits controlling said mechanisms, a circuit sensitive to the waves or disturbances of the source and means therein adapted to control the said local circuits, as and for the purpose set forth.

8、存在一个组合，它包括电波或电扰动的一个来源、用于开启和停止该来源的操作的工具，一个船只或车辆，以及由此承载的推进和转向机械装置、控制所述工具的局部电路、对电波或电扰源敏感的电路以及其中适于控制所述一个局部电路，用于如前所述的目的。

9. The sensitive device herein described comprising in construction a receptacle containing a material such as particles of oxidized metal forming a part of the circuit, and means for turning the same end for end when the material has been rendered active by the passage through it of an electric discharge, as set forth.

9、这里描述的敏感装置在结构上包括一个容器，该容器容纳一种材料，例如形成电路的一部分的金属氧化颗粒、以及用于当该材料通过放电通道被激活时，调头转动该材料的工具，如前所述。

10. The sensitive device herein described, comprising in combination a receptacle containing a material such as particles of oxidized metal forming a part of an electric circuit, an electromagnet in said circuit, and devices controlled thereby for turning the receptacle end for end when said magnet is energized, as set forth.

10、本文所述的敏感装置包括：一个容器，该容器容纳诸如形成电路一部分的金属氧化颗粒的一种材料、所述电路中的一个电磁体、以及由此控制的装置，该装置用于在所述磁体通电时调头地转动容器，如前所述。

11. The sensitive device herein described, comprising in combination a receptacle containing a material such as particles of oxidized metal forming part of an electric circuit, a motor for rotating the receptacle, an electromagnet in circuit with the material, and an escapement controlled by said magnet and adapted to permit a half-revolution of the receptacle when the said magnet is energized, as set forth.

11、本文所述的敏感装置包括：一个容器，该容器容纳诸如形成电路一部分的金属氧化颗粒的一种材料、用于旋转该容器的一个电动机、在电路中具有该材料的一个电磁体、以及由所述磁体控制的擒纵机构，该擒纵机构适于在所述磁体通电时允许该容器旋转半周，如前所述。

12. The combination with a movable body or vehicle, of a propelling-motor, a steering-motor and electrical contacts carried by a moving portion of the steering mechanism, and adapted in certain positions of the latter to interrupt the circuit of the propelling-motor, a local circuit and means connected therewith for controlling the steering-motor, and a circuit controlling the local circuit and means for rendering said controlling-circuit sensitive to the influence of electric waves or disturbances exerted at a distance from their source, as set forth.

12、存在一个组合，它包括一个可移动体或交通工具，它由推进一个电动机、一个操舵电动机和由操舵机械装置的移动部分携带的电触点组成，这些电触点适于在自身的某些位置中断推进电动机的电路，还包括一个局部电路和与之连接的用于控制操舵电动机的工具，以及控制该局部电路的一个电路和用于使所述控制电路对在远离一个来源的地方施加的电波或电扰动的影响敏感的工具，如前所述。

13. The combination with the steering-motor, a local circuit for directing current through the same in opposite directions, a controlling-circuit rendered sensitive to the influence of electric waves or disturbances exerted at a distance from their source, a motor in circuit with the steering-motor but adapted to run always in the same direction, and a local circuit or circuits controlled by said motor, as set forth.

13、存在一个组合，它包括操舵电动机、用于引导电流沿相反方向通过操舵电动机的一个局部电路、一种控制电路，它对从一个远距离的源头所施加的电波或电扰动的影响敏感、在具有操舵电动机的一个电路中的一个电动机，但总适用于与该操舵电动机同向转动、由所述电动机控制的一个局部电路或不同的局部电路，如前所述。

NIKOLA TESLA.

尼古拉·特斯拉

Witnesses:

RAPHAËL NETTER,

GEORGE SCHERFF.

见证人:

拉斐尔·奈特、乔治·舍夫。

No. 613,809.

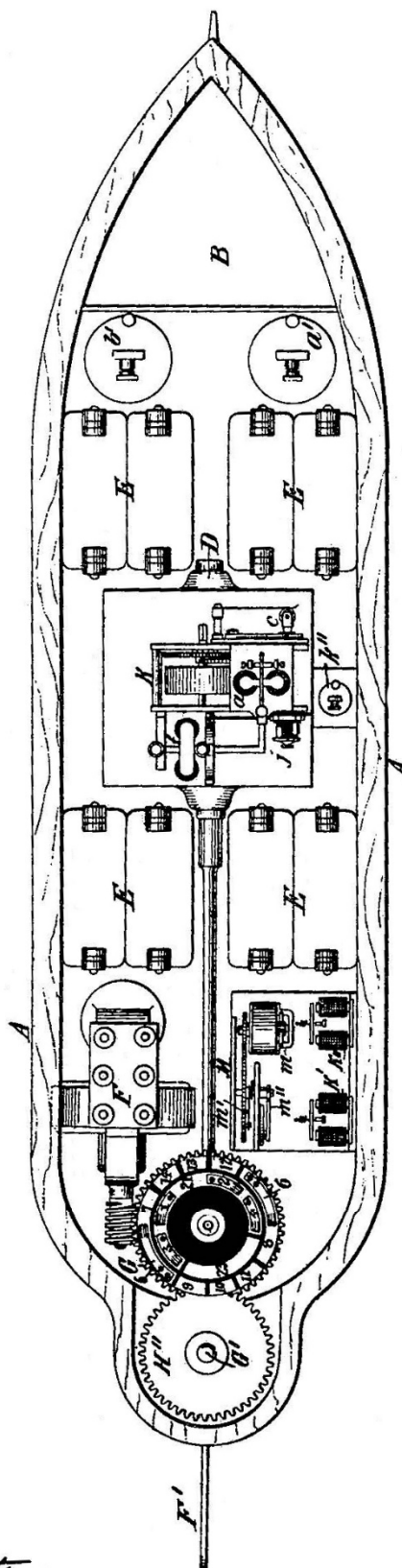
Patented Nov. 8, 1898.

N. TESLA.

**METHOD OF AND APPARATUS FOR CONTROLLING MECHANISM OF MOVING VESSELS
OR VEHICLES.**

(No Model.)

5 Sheets—Sheet 1.



Witnesses:
Raphael Ketter
George Scherff.

Inventor
Nikola Tesla

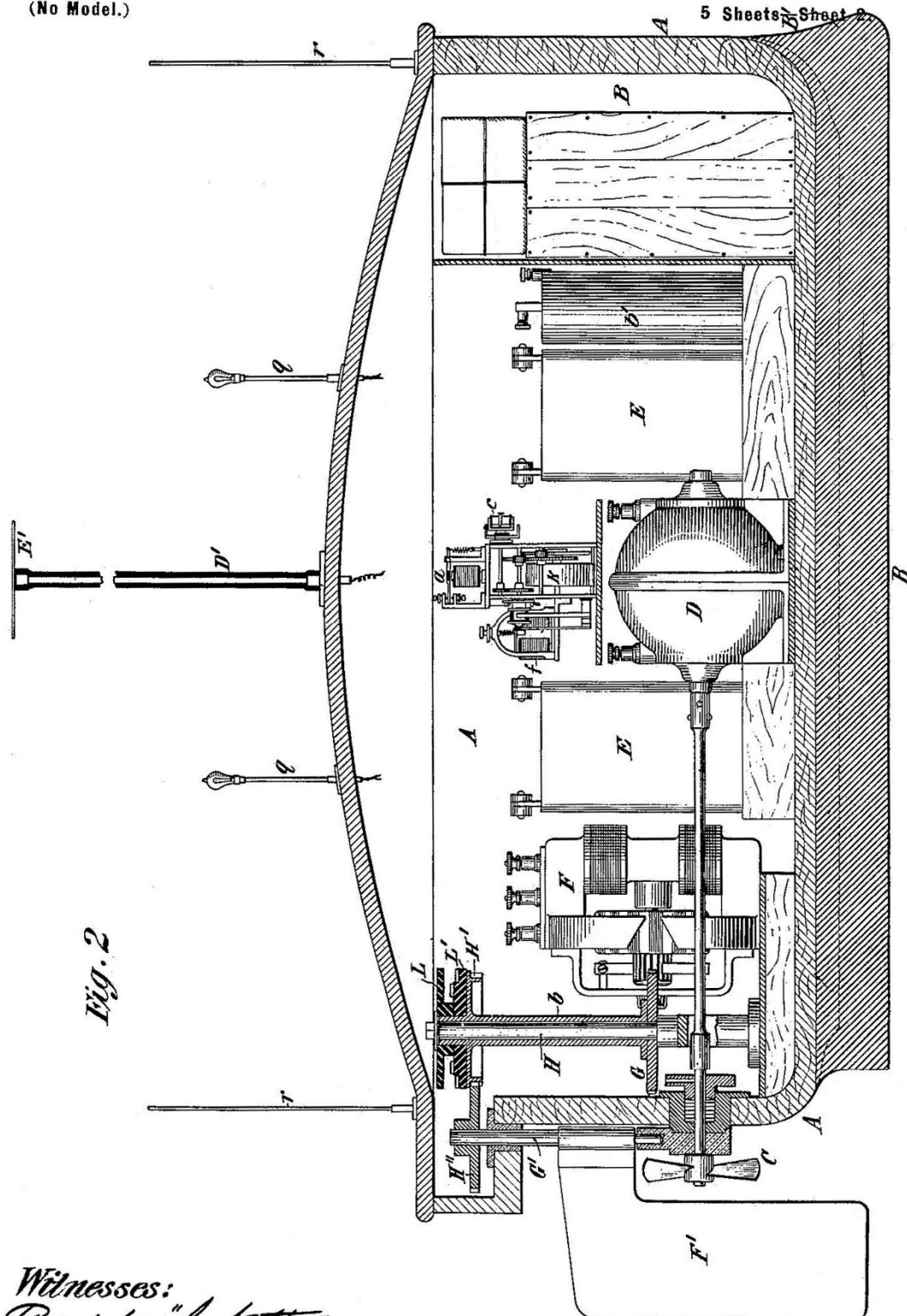
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5 Sheets—Sheet 3.

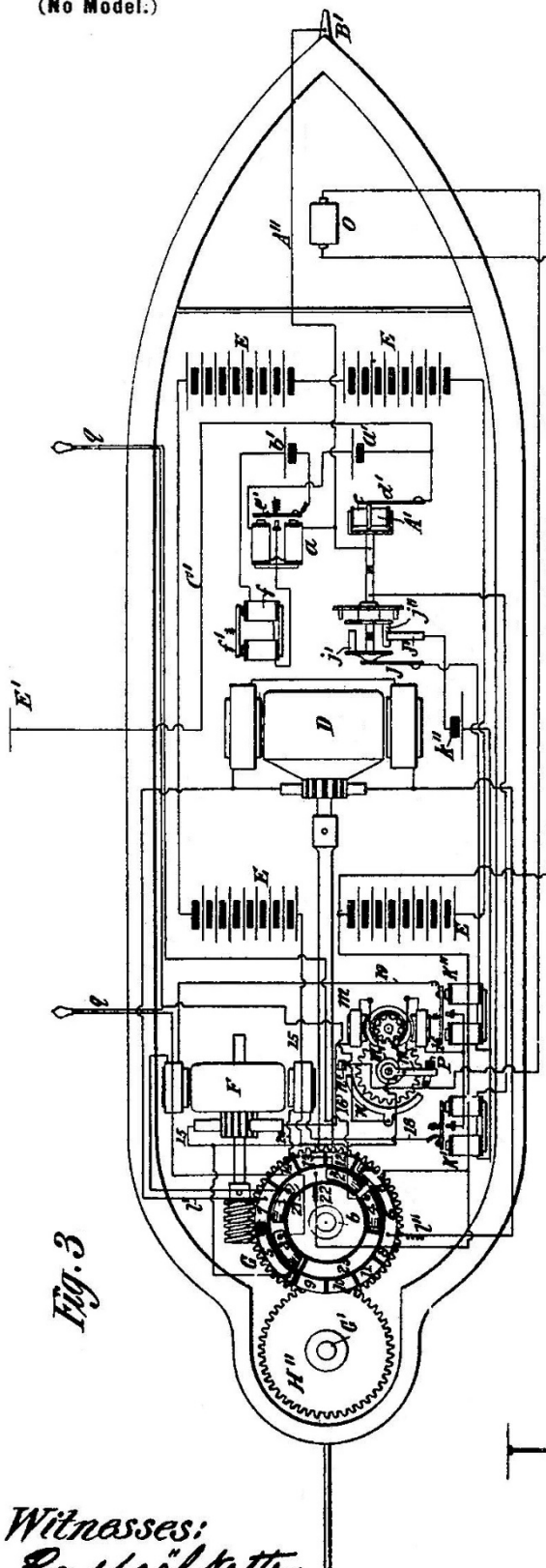


Fig. 3

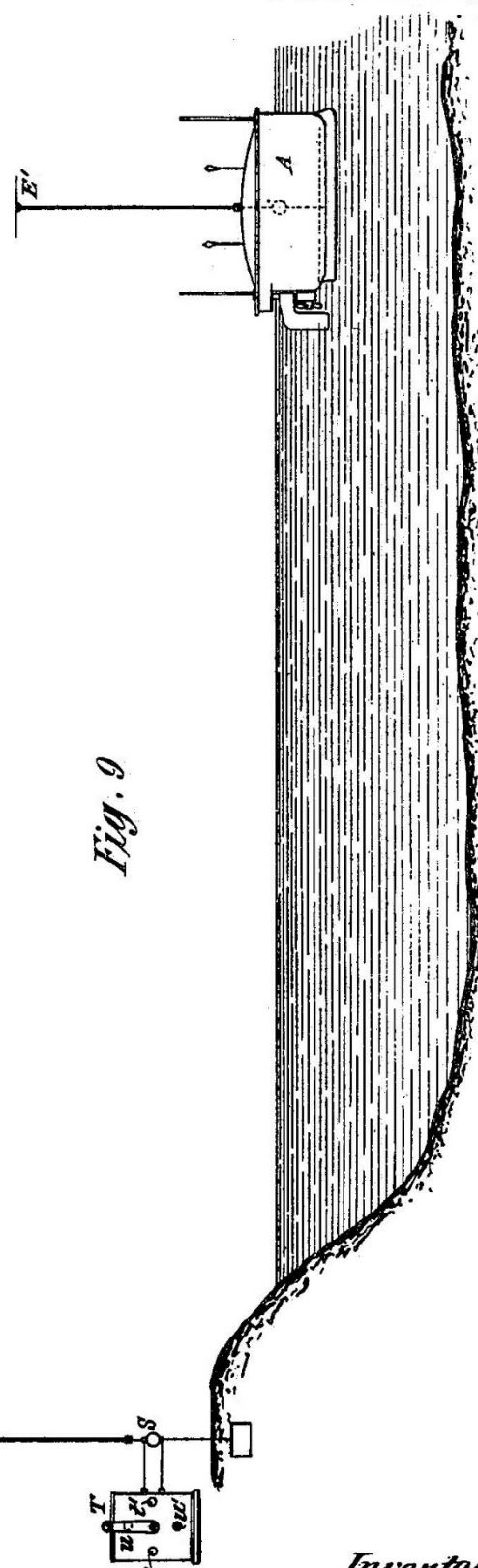


Fig. 9

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No. 613,809.

Patented Nov. 8, 1898.

N. TESLA.

METHOD OF AND APPARATUS FOR CONTROLLING MECHANISM OF MOVING VESSELS
OR VEHICLES.

(No Model.)

5 Sheets—Sheet 4.

Fig. 5

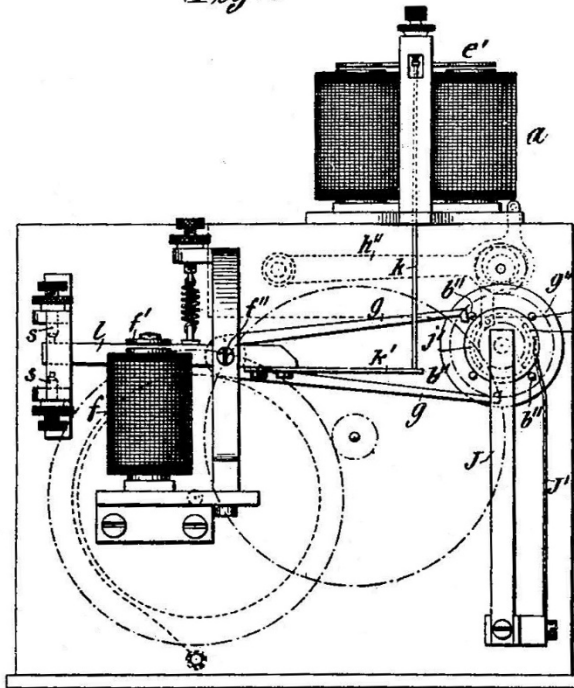


Fig. 6

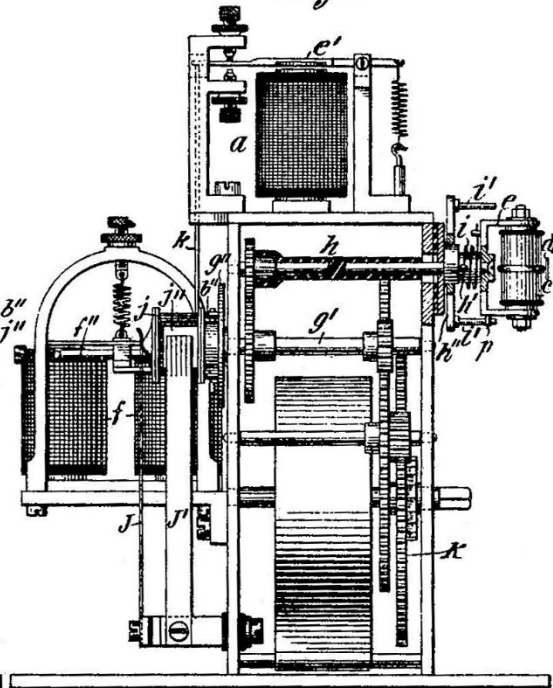


Fig. 4

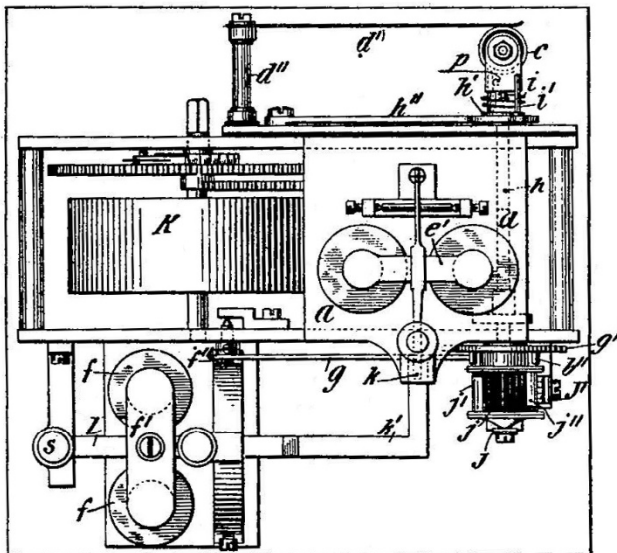


Fig. 8

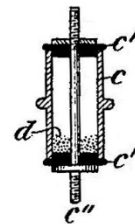
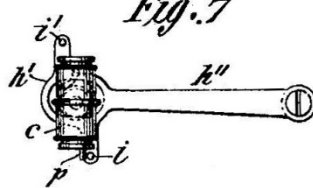


Fig. 7



Witnesses:
Raphaël Vetter
George Scherff.

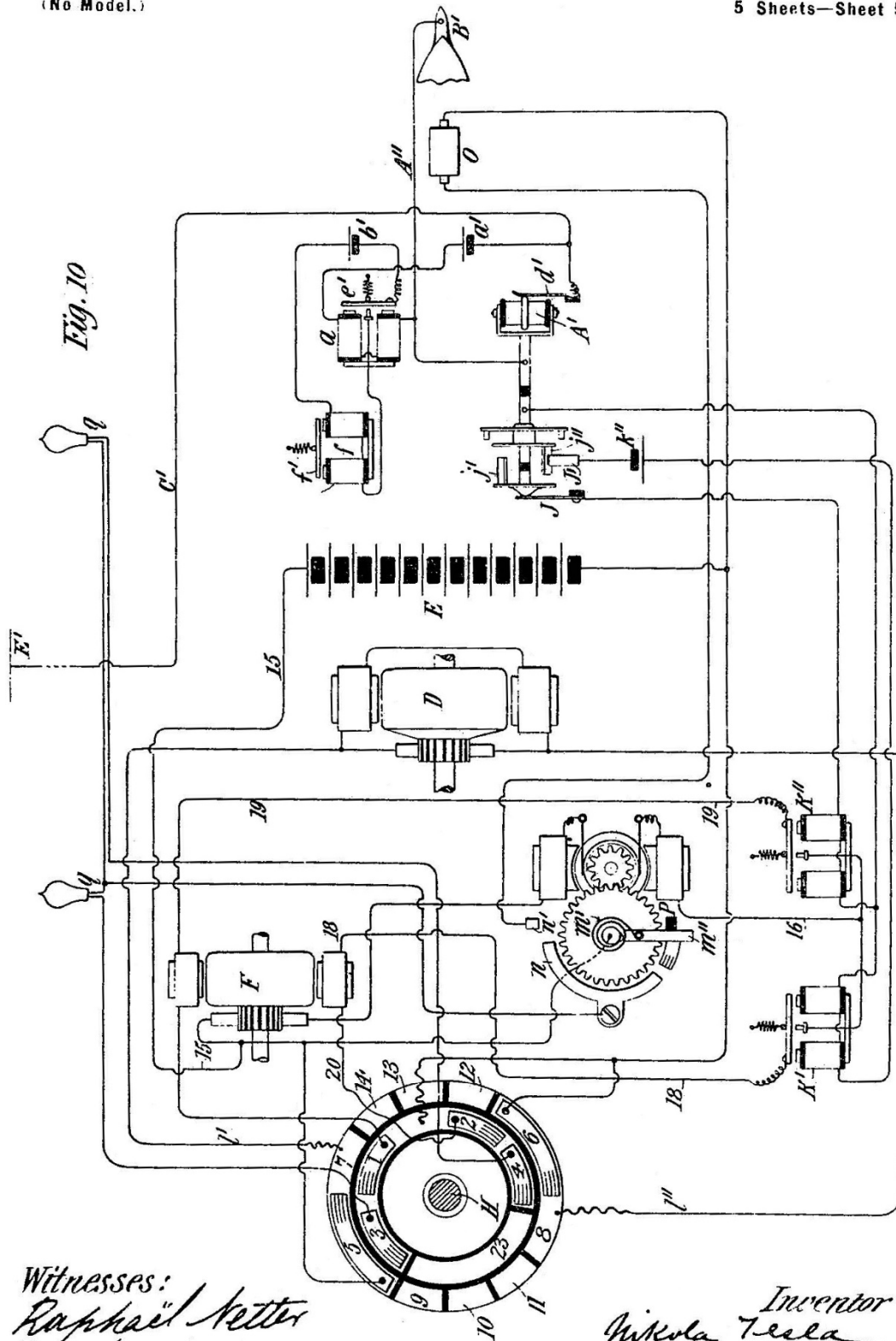
Inventor:
Nikola Tesla

N. TESLA.

METHOD OF AND APPARATUS FOR CONTROLLING MECHANISM OF MOVING VESSELS
OR VEHICLES.

(No Model.)

5 Sheets—Sheet 5.



Witnesses:
Raphaël Ketter
Dr. Lammou Dyer.

Inventor
Nikola Tesla
By Kerr, Curtis & Page
attys.

SYSTEM OF TRANSMISSION OF ELECTRICAL ENERGY.

电能传输系统

NIKOLA TESLA, OF NEW YORK, N. Y.

纽约州纽约市的尼古拉·特斯拉

SPECIFICATION forming part of Letters Patent No. 645,576, dated March 20, 1900.

Application filed September 2, 1897. Serial No. 650,343. (No model.)

该说明书形成了颁发于 1900 年 3 月 20 日编号为 645,576 的专利证书的一部分。

申请于 1897 年 9 月 2 日提交，序列号为 650,343。(无模型)

To all whom it may concern:

致所有有关人士：

Be it known that I, NIKOLA TESLA, a citizen of the United States, residing at New York, in the county and State of New York, have invented certain new and useful Improvements in Systems of Transmission of Electrical Energy, of which the following is a specification, reference being had to the drawing accompanying and forming a part of the same.

我、尼古拉·特斯拉、一个美国公民，居住在纽约州纽约郡纽约市，在电能传输系统方面已经发明了某些新的有用的改进，以下是该发明的一个说明，必须参考随附的图纸，它已形成了该说明书的一部分。

It has been well known heretofore that by rarefying the air enclosed in a vessel its insulating properties are impaired to such an extent that it becomes what may be considered as a true conductor, although one of admittedly very high resistance. The practical information in this regard has been derived from observations necessarily limited in their scope by the character of the apparatus or means heretofore known and the quality of the electrical effects producible thereby. Thus it has been shown by William Crookes in his classical researches, which have so far served as the chief source of knowledge of this subject, that all gases behave as excellent insulators until rarefied to a point corresponding to a barometric pressure of about seventy-five millimeters, and even at this very low pressure the discharge of a high-tension induction-coil passes through only a part of the attenuated gas in the form of a luminous thread or arc, a still further and considerable diminution of the pressure being required to render the entire mass of the gas enclosed in a vessel conducting. While this is true in every particular so long as electromotive or current impulses such as are obtainable with ordinary forms of apparatus are employed, I have found that neither the general behavior of the gases nor the known relations between electrical conductivity and barometric pressure are in conformity with these observations when impulses are used such as are producible by methods and apparatus devised by me and which have peculiar and hitherto unobserved properties and are of effective electromotive forces, measuring many hundred thousands or millions of volts. Through the continuous perfection of these methods and

apparatus and the investigation of the actions of these current impulses I have been led to the discovery of certain highly-important and useful facts which have hitherto been unknown. Among these and bearing directly upon the subject of my present application are the following: First, that atmospheric or other gases, even under normal pressure, when they are known to behave as perfect insulators, are in a large measure deprived of their dielectric properties by being subjected to the influence of electromotive impulses of the character and magnitude I have referred to and assume conducting and other qualities which have been so far observed only in gases greatly attenuated or heated to a high temperature, and, second, that the conductivity imparted to the air or gases increases very rapidly both with the augmentation of the applied electrical pressure and with the degree of rarefaction, the law in this latter respect being, however, quite different from that heretofore established. In illustration of these facts a few observations, which I have made with apparatus devised for the purposes here contemplated, may be cited. For example, a conductor or terminal, to which impulses such as those here considered are supplied, but which is otherwise insulated in space and is remote from any conducting-bodies, is surrounded by a luminous flame-like brush or discharge often covering many hundreds or even as much as several thousands of square feet of surface, this striking phenomenon clearly attesting the high degree of conductivity which the atmosphere attains under the influence of the immense electrical stresses to which it is subjected. This influence is, however, not confined to that portion of the atmosphere which is discernible by the eye as luminous and which, as has been the case in some instances actually observed, may fill the space within a spherical or cylindrical envelop of a diameter of sixty feet or more, but reaches out to far remote regions, the insulating qualities of the air being, as I have ascertained, still sensibly impaired at a distance many hundred times that through which the luminous discharge projects from the terminal and in all probability much farther. The distance extends with the increase of the electromotive force of the impulses, with the diminution of the density of the atmosphere, with the elevation of the active terminal above the ground, and also, apparently, in a slight measure, with the degree of moisture contained in the air. I have likewise observed that this region of decidedly-noticeable influence continuously enlarges as time goes on, and the discharge is allowed to pass not unlike a congregation which slowly spreads, this being possibly due to the gradual electrification or ionization of the air or to the formation of less insulating gaseous compounds. It is, furthermore, a fact that such discharges of extreme tensions, approximating those of lightning, manifest a marked tendency to pass upward away from the ground, which may be due to electrostatic repulsion, or possibly to slight heating and consequent rising of the electrified or ionized air. These latter observations make it appear probable that a discharge of this character allowed to escape into the atmosphere from a terminal maintained at a great height will gradually leak through and establish a good conducting-path to more elevated and better conducting air strata, a process which possibly takes place in silent lightning discharges frequently witnessed on hot and sultry days. It will be apparent to what an extent the conductivity imparted to the air is enhanced by the increase of the electromotive force of the impulses when it is stated that in some instances the area covered by the flame discharge mentioned was enlarged more than six fold by an augmentation of the electrical pressure, amounting scarcely to more than fifty percent. As to the influence of rarefaction upon the electric conductivity imparted to the gases it is noteworthy that, whereas the atmospheric or other gases begin ordinarily to manifest this quality at something like seventy-five millimeters barometric pressure with the impulses of excessive electromotive force to which I have referred, the conductivity, as already pointed out, begins even at normal pressure and continuously increases with the degree of tenuity of the gas, so that at, say, one hundred and thirty millimeters pressure, when the gases are known to be still nearly perfect insulators for ordinary electromotive forces, they behave toward electromotive impulses of several millions of volts like

excellent conductors, as though they were rarefied to a much higher degree. By the discovery of these facts and the perfection of means for producing in a safe, economical, and thoroughly-practicable manner current impulses of the character described it becomes possible to transmit through easily-accessible and only moderately-rarefied strata of the atmosphere electrical energy not merely in insignificant quantities, such as are suitable for the operation of delicate instruments and like purposes, but also in quantities suitable for industrial uses on a large scale up to practically any amount and, according to all the experimental evidence I have obtained, to any terrestrial distance. To conduce to a better understanding of this method of transmission of energy and to distinguish it clearly, both in its theoretical aspect and in its practical bearing, from other known modes of transmission, it is useful to state that all previous efforts made by myself and others for transmitting electrical energy to a distance without the use of metallic conductors, chiefly with the object of actuating sensitive receivers, have been based, in so far as the atmosphere is concerned, upon those qualities which it possesses by virtue of its being an excellent insulator, and all these attempts would have been obviously recognized as ineffective if not entirely futile in the presence of a conducting atmosphere or medium. The utilization of any conducting properties of the air for purposes of transmission of energy has been hitherto out of the question in the absence of apparatus suitable for meeting the many and difficult requirements, although it has long been known or surmised that atmospheric strata at great altitudes—say fifteen or more miles above sea-level—are, or should be, in a measure, conducting; but assuming even that the indispensable means should have been produced then still a difficulty, which in the present state of the mechanical arts must be considered as insuperable, would remain—namely, that of maintaining terminals at elevations of fifteen miles or more above the level of the sea. Through my discoveries before mentioned and the production of adequate means the necessity of maintaining terminals at such inaccessible altitudes is obviated and a practical method and system of transmission of energy through the natural media is afforded essentially different from all those available up to the present time and possessing, moreover, this important practical advantage, that whereas in all such methods or systems heretofore used or proposed but a minute fraction of the total energy expended by the generator or transmitter was recoverable in a distant receiving apparatus by my method and appliances it is possible to utilize by far the greater portion of the energy of the source and in any locality however remote from the same.

迄今为止众所周知的是，通过使封闭在容器中的空气变稀薄，其绝缘性能被削弱到这样一种程度，以致于它成为可以被认为是真正的导体，尽管它确实具有非常高的电阻。这方面的实际信息是从观测中得到的，这些观测的范围必然受限于迄今已知的装置或工具的特性以及由此产生的电效应的质量。因此，威廉·克鲁克斯在他的经典研究中已经表明，到目前为止，作为这一主题的主要知识来源，所有的气体都表现为优秀的绝缘体，直到稀薄到一个点，对应于大约 75 毫米的大气压力，即使在这种非常低的压力下，高压感应线圈的放电以发光线或电弧形式仅通过一部分衰减气体，还需要进一步显著降低压力，以使封闭在容器中的全部气体导电。虽然这在每一个特定的情况下都是正确的，只要使用了用普通形式的装置也可以获得电动势脉冲或电流脉冲，但我发现，当使用脉冲时，无论是气体的一般行为还是电导率和大气压力之间的已知关系都与这些观察结果不一致，例如由我设计的方法和装置可以产生的脉冲，这些脉冲具有古怪的迄今未观察到的特性，并且具有有效的电动势，测量到数十万或数百万伏。通过这些方法和装置的不完善，以及对这些电流脉冲作用的研究，我发现了一些至今未知的非常重要和有用的事实。其中与我目前申请的主题直接相关的有：第一，大气或其他气体，即使在正常压力下，当它们被认为表现为完美的绝缘体时，在很大程度上由于受到我所提到的特征和大小的电动势脉冲的影响而被剥夺了它们的介电特性，并假定它们

的导电和其他性质,这些性质迄今为止只在被大大衰减或加热到高温的气体中观察到,第二,赋予空气或气体的可传导性随着所施加的电压力的增加和稀薄程度的增加而非常迅速地增加,然而,后一方面的规律与迄今为止所建立的规律大不相同。在这些事实的说明中,可以引用一些观察结果,这些观察结果是我用为这里所设想的目的而设计的仪器得出的。例如,一个导体或终端,如这里所考虑的脉冲被提供给它,但它在空间中是绝缘的并且远离任何其他导电体,它会被一个发光的火焰状刷子或放电包围,通常覆盖数百甚至数千平方英尺的表面,这种惊人的现象清楚地证明了大气在其承受的巨大电应力的影响下获得的高度导电性。然而,这种影响并不局限于肉眼可识别为发光的那部分大气,并且正如在某些情况下实际观察到的那样,可能会充满直径为 60 英尺或更大的球形或圆柱形外壳内的空间,但是会延伸到很远的地区,正如我已经确定的那样,在发光放电从终端发射出的数百倍的距离处,空气的绝缘质量仍然明显受损,而且很可能要远得多更多。随着脉冲的电动势的增加,随着大气密度的减小,随着活跃终端离地高度的升高,以及显然在轻微的程度,随着空气中所含水分的程度,这种距离会延长。我同样观察到,随着时间的推移,这一具有明显的影响区域不断扩大,放电被允许通过,不像一个缓慢扩散的集会,这可能是由于空气逐渐带电或电离,或形成绝缘较低的气体化合物。此外,存在一个事实,这种极端张力的近似于闪电的放电,表现出明显的从地面向上传递的趋势,这可能是由于静电排斥,或可能是轻微的加热和随之而来的带电或电离的空气的上升。后面的这些观察表明,这种特征的放电似乎很可能从保持在一个很高高度的终端逃逸到大气中,将逐渐泄漏并建立一个良好的传导路径,通向更高和更好的传导空气层,这一过程可能发生在炎热和闷热的日子里经常目睹到的无声闪电的放电中。当在某些情况下所述火焰放电所覆盖的区域由于增加了电压力而扩大了六倍以上时,很明显,通过脉冲电动势的增加,赋予空气的传导性提高到了几乎不超过百分之五十的程度。至于稀薄化对赋予气体的电导率的影响,值得注意的是,尽管大气或其他气体通常在大约 75 毫米大气压下用我提到的过度电动势的脉冲开始表现出这种性质,但正如已经指出的,电导率甚至在正常压力下开始,并随着气体的稀薄程度的增加而持续增加,因此,在例如 130 毫米的压力下,当已知气体仍然是普通电动势的几乎完美的绝缘体时,它们对几百万伏的电动势有反应,就像优秀的导体一样,就好像它们被稀释到更高的程度。通过这些事实的发现和以安全、经济和完全可行的方式将产生所述特征电流脉冲的工具进行完善,有可能通过易于获取的和仅适度稀薄的大气层来传输电能,不仅可以是微不足道的数量,例如适合于精密仪器的操作和类似目的,而且也可以是适合于大规模工业应用可以达到的实际上的任何数量,并且根据我所获得的所有实验证据,可以传输到地球上的任何距离。为了有助于更好地理解这种能量传输方法,并从理论上和实际意义上清楚地将其与其他已知的传输方式明确地区分开来,有必要说明的是,我自己和其他人以前为在不使用金属导体的情况下将电能传输到远处所做的所有努力,主要目的是为了激发灵敏的接收器,就大气而言,是基于它作为一种极好的绝缘体所具有的那些特质,所有这些尝试如果不是完全无效的话,那么在有导电的大气或媒介存在的情况下显然是无效的。迄今为止,在没有适合满足许多困难要求的仪器的情况下,利用空气的任何传导特性来传输能量是不可能的,尽管长期以来人们已经知道或推测,在很高的高度——比如说海拔 15 英里或更高——那里大气层在某种程度上是传导的,或者应该在一定程度上是传导的;但是,即使假设已经生产了不可或缺的工具,那么仍然存在一个困难,在目前的机械技术状态下,这个困难一定被认为是不可克服的,也就是说,将终端维持在高于海平面十五英里或更高的高度上。通过我前面提到的发现和适当工具的生产,消除了将终端保持在这种难以接近的高度的必要性,并且提供了一种通过自然媒介传输能量的实用方法和系统,本质上不同于到目前为止所有可用的方法和系统,并且还具有这种重要的实用优势,尽管在迄今为止使用或提出的所有这种方法或系统中,发电机或发射机消耗的总能量中只有很小一部分通过我的方法和设备在远处的接收设备中是可以回收的,但是在任何远离能量源的地方利用该能量源的大部分能量是可能的。

Expressed briefly, my present invention, based upon these discoveries, consists then in producing at one point an electrical pressure of such character and magnitude as to cause thereby a current to traverse elevated strata of the air between the point of generation and a distant point at which the energy is to be received and utilized.

简而言之，基于这些发现，我的本发明是在一个点上产生一个电压力，该电压力的性质和大小使得电流在产生点和能量被接收和利用的远处点之间穿过高空的空气层。

In the accompanying drawing a general arrangement of apparatus is diagrammatically illustrated such as I contemplate employing in the carrying out of my invention on an industrial scale—as, for instance, for lighting distant cities or districts from places where cheap power is obtainable.

在附图中，示意性地展示了该装置的总体布置，例如我打算在工业规模上实施我的发明中所使用的装置，例如，用于从可获得廉价电力的地方照亮遥远的城市或地区。

Referring to the drawing, A is a coil, generally of many turns and of a very large diameter, wound in spiral form either about a magnetic core or not, as may be found necessary. C is a second coil, formed of a conductor of much larger section and smaller length, wound around and in proximity to the coil A. In the transmitting apparatus the coil A constitutes the high-tension secondary and the coil C the primary of much lower tension of a transformer. In the circuit of the primary C is included a suitable source of current G. One terminal of the secondary A is at the center of the spiral coil, and from this terminal the current is led by a conductor B to a terminal D, preferably of large surface, formed or maintained by such means as a balloon at an elevation suitable for the purposes of transmission, as before described. The other terminal of the secondary A is connected to earth and, if desired, also to the primary in order that the latter may be at substantially the same potential as the adjacent portions of the secondary, thus insuring safety. At the receiving-station a transformer of similar construction is employed; but in this case the coil A', of relatively-thin wire, constitutes the primary and the coil C', of thick wire or cable, the secondary of the transformer. In the circuit of the latter are included lamps L, motors M, or other devices for utilizing the current. The elevated terminal D' is connected with the center of the coil A', and the other terminal of said coil is connected to earth and preferably, also, to the coil C' for the reasons above stated.

参考附图，A 是一个线圈，通常具有许多匝并且具有非常大的直径，如有必要，会以螺旋形式缠绕在磁芯上或者不缠绕在磁芯上。C 是第二线圈，由截面大得多、长度小得多的导体形成，缠绕在线圈 A 的周围和附近。在发射装置中，线圈 A 构成变压器的高压次级线圈，线圈 C 构成变压器的电压低得多的初级线圈。初级 C 的电路包括一个合适的电流源 G，次级线圈 A 的一个终端位于螺旋线圈的中心，并且电流从该终端由导体 B 引导至一个终端 D，终端 D 最好具有大的表面，由诸如气球的工具来形成或保持在适于传输目的的高度，如前所述。次级 A 的另一个终端接地，并且如果需要，还连接到初级，以便初级可以与次级的相邻部分处于基本相同的电势，从而确保安全。在接收站，有一个采用了类似结构的变压器；但是在这种情况下，相对较细导线的线圈 A' 构成变压器的初级线圈，而采用粗导线或电缆的线圈 C' 构成变压器的次级线圈。后者的电路包括灯 L、电动机 M 或其它利用电流的装置。高架终端 D' 与线圈 A' 的中心连接，并且所述线圈的另一个终端接地，并且出于上述原因，也优选地连接到线圈 C'。

It will be observed that in coils of the character described the potential gradually increases with the number of turns toward the center, and the difference of potential between the adjacent turns being comparatively small, a very high potential, impracticable with ordinary coils, may be successfully obtained. It will be, furthermore, noted that no matter to what an extent the coils may be modified in design and construction, owing to their general arrangement and manner of connection, as illustrated, those portions of the wire or apparatus which are highly charged will be out of reach, while those parts of the same which are liable to be approached, touched, or handled will be at or nearly the same potential as the adjacent portions of the ground, this insuring, both in the transmitting and receiving apparatus and regardless of the magnitude of the electrical pressure used, perfect personal safety, which is best evidenced by the fact that although such extreme pressures of many millions of volts have been for a number of years continuously experimented with no injury has been sustained neither by myself or any of my assistants.

将会观察到,在所述特征的线圈中,电势随着指向中心的匝数而逐渐增加,并且相邻匝之间的电势差相对较小,可以成功地获得一个非常高的电势,这对于普通线圈是不可行的。此外,应该注意的是,无论线圈在设计和构造上可以被修改到何种程度,由于它们的总体布置和连接方式,如图所示,电线或装置的那些高度充电的部分将是远离触及的,而电线或设备的那些易于接近、接触或处理的部分将处于或接近与接地的相邻部分的相同电势,这确保了无论在发射和接收设备中,也无论所使用的电压的大小如何,都是完美的人身安全,这最好地证明了这样一个事实,即尽管数百万伏的这种极端电压已经连续试验了许多年,但我本人或我的任何助手都没有受到伤害。

The length of the thin-wire coil in each transformer should be approximately one-quarter of the wave length of the electric disturbance in the circuit, this estimate being based on the velocity of propagation of the disturbance through the coil itself and the circuit with which it is designed to be used. By way of illustration if the rate at which the current traverses the circuit, including the coil, be one hundred and eighty-five thousand miles per second then a frequency of nine hundred and twenty-five per second would maintain nine hundred and twenty-five stationary waves in a circuit one hundred and eighty-five thousand miles long and each wave would be two hundred miles in length. For such a low frequency, to which I shall resort only when it is indispensable to operate motors of the ordinary kind under the conditions above assumed, I would use a secondary of fifty miles in length. By such an adjustment or proportioning of the length of wire in the secondary coil or coils the points of highest potential are made to coincide with the elevated terminals D D', and it should be understood that whatever length be given to the wires this condition should be complied with in order to attain the best results.

每个变压器中细导线线圈的长度应该大约是电路中电扰动波长的四分之一,这个估计值是基于扰动通过线圈本身和电路的传播速度。举例来说,如果电流通过包括线圈在内的电路的速率为每秒 185,000 英里,那么每秒 925 的频率将在 185,000 英里长的电路中保持 925 个静态波,每个波的长度为 200 英里。对于如此低的频率,只有当在上述假设的条件下,普通类型的电动机运行变得不可或缺时,我才会使用 50 英里长的次级线圈。通过对次级线圈中的导线长度进行这种调整或配比,使最高电位点与高架终端 D D'重合,应该理解,无论导线的长度是多少,都应该符合这一条件,以获得最佳结果。

As the main requirement in carrying out my invention is to produce currents of an excessively-high potential, this object will be facilitated by using a primary current of very considerable frequency, since

the electromotive force obtainable with a given length of conductor is proportionate to the frequency; but the frequency of the current is in a large measure arbitrary, for if the potential be sufficiently high and if the terminals of the coils be maintained at the proper altitudes the action described will take place, and a current will be transmitted through the elevated air strata, which will encounter little and possibly even less resistance than if conveyed through a copper wire of a practicable size. Accordingly the construction of the apparatus may be in many details greatly varied; but in order to enable any person skilled in the mechanical and electrical arts to utilize to advantage in the practical applications of my system the experience I have so far gained the following particulars of a model plant which has been long in use and which was constructed for the purpose of obtaining further data to be used in the carrying out of my invention on a large scale are given. The transmitting apparatus was in this case one of my electrical oscillators, which are transformers of a special type, now well known and characterized by the passage of oscillatory discharges of a condenser through the primary. The source G, forming one of the elements of the transmitter, was a condenser of a capacity of about four one-hundredths of a microfarad and was charged from a generator of alternating currents of fifty thousand volts pressure and discharged by means of a mechanically-operated break five thousand times per second through the primary C. The latter consisted of a single turn of stout stranded cable of inappreciable resistance and of an inductance of about eight thousand centimeters, the diameter of the loop being very nearly two hundred and forty-four centimeters. The total inductance of the primary circuit was approximately ten thousand centimeters, so that the primary circuit vibrated generally according to adjustment, from two hundred and thirty thousand to two hundred and fifty thousand times per second. The high-tension coil A in the form of a flat spiral was composed of fifty turns of heavily-insulated cable No. 8 wound in one single layer, the turns beginning close to the primary loop and ending near its center. The outer end of the secondary or high-tension coil A was connected to the ground, as illustrated, while the free end was led to a terminal placed in the rarefied air stratum through which the energy was to be transmitted, which was contained in an insulating-tube of a length of fifty feet or more, within which a barometric pressure varying from about one hundred and twenty to one hundred and fifty millimeters was maintained by means of a mechanical suction-pump. The receiving-transformer was similarly proportioned, the ratio of conversion being the reciprocal of that of the transmitter, and the primary high-tension coil A' was connected, as illustrated, with the end near the low-tension coil C' to the ground and with the free end to a wire or plate likewise placed in the rarefied air stratum and at the distance named from the transmitting-terminal. The primary and secondary circuits in the transmitting apparatus being carefully synchronized, an electromotive force from two to four million volts and more was obtainable at the terminals of the secondary coil A, the discharge passing freely through the attenuated air stratum maintained at the above barometric pressures, and it was easy under these conditions to transmit with fair economy considerable amounts of energy, such as are of industrial moment, to the receiving apparatus for supplying from the secondary coil C' lamps L or kindred devices. The results were particularly satisfactory when the primary coil or system A', with its secondary C', was carefully adjusted, so as to vibrate in synchronism with the transmitting coil or system A C. I have, however, found no difficulty in producing with apparatus of substantially the same design and construction electromotive forces exceeding three or four times those before mentioned and have ascertained that by their means current impulses can be transmitted through much-denser air strata. By the use of these I have also found it practicable to transmit notable amounts of energy through air strata not in direct contact with the transmitting and receiving terminals, but remote from them, the action of the impulses, in rendering conducting air of a density at which it normally behaves as an insulator, extending, as before remarked, to a considerable distance. The high electromotive force obtained at the terminals of

coil or conductor A was, as will be seen, in the preceding instance, not so much due to a large ratio of transformation as to the joint effect of the capacities and inductances in the synchronized circuits, which effect is enhanced by a high frequency, and it will be obviously understood that if the latter be reduced a greater ratio of transformation should be resorted to, especially in cases in which it may be deemed of advantage to suppress as much as possible, and particularly in the transmitting-coil A, the rise of pressure due to the above effect and to obtain the necessary electromotive force solely by a large transformation ratio.

由于在实施我的发明中的主要要求是产生一个过高电势的电流,这个目的将通过使用一个相当大频率的初级电流来实现,因为用给定长度的导体获得的电动势与频率成比例;但是电流的频率在很大程度上是任意的,因为如果电势足够高,并且如果线圈的终端保持在适当的高度,所描述的作用将会发生,并且电流将通过高空的空气层传输,这将遇到很小的阻力,甚至可能比通过实际尺寸的铜线传输的阻力更小。因此,该装置的结构在许多细节上可以有很大的不同;但是为了使任何机械和电气领域的技术人员能够在我的系统的实际应用中有利地利用我迄今为止获得的经验,到目前为止,我已经获得了关于一个模型工厂的以下详细信息,该模型工厂已长期使用并给出了获取的更多数据以用于大规模实施我的发明。在这种情况下,发射装置是我的一个电子振荡器,它是一种特殊类型的变压器,现在已广为人知,其特点是一个电容器的振荡放电通过初级线圈。构成发射机的一个组件的电源 G 是一个电容量约为百分之四微法的电容器,由一个电压为五万伏的交流发电机充电,并利用一个机械操作的断路器通过初级线圈 C 每秒放电五千次。后者是由一圈粗壮的绞合电缆组成的,它的电阻和电感都很小,约为 8000 厘米,环路的直径接近 244 厘米。初级电路的总电感约为一万厘米,因此初级电路通常根据调整而振动,从每秒二十三万次到二十五万次。扁平螺旋形式的高压线圈 A 由 50 匝高度绝缘的 8 号电缆组成,缠绕在一个单层中,匝圈开始于初级环路附近,结束于其中心附近。如图所示,次级线圈或高压线圈 A 的外端连接到地面,而游离端连接到被放置在稀薄空气层中的终端上,能量通过该终端传输,该终端被包含在长度为 50 英尺或更长的绝缘管中,在该绝缘管中,通过机械抽吸泵将大气压力保持在大约 120 到 150 毫米之间。接收变压器的比例类似,转换比是发射机的倒数,如图所示,初级高压线圈 A' 的两个终端中的靠近低压线圈 C' 的那个终端接地,游离端与同样位于稀薄空气层中的导线或板相连,并与发射终端保持一定距离。发射装置中的初级和次级电路被小心地同步,在次级线圈 A 的终端可获得从 200 万伏到 400 万伏甚至更多的电动势,放电自由地通过保持在上述大气压下的衰减空气层,并且在这些条件下很容易以相当经济的方式向接收装置发射大量能量,例如工业用电,用于从次级线圈 C' 向电灯 L 或类似装置供电。当初级线圈或系统 A' 及其次级线圈 C' 被仔细调整,以便与发射线圈或系统 A C 同步振动时,结果特别令人满意。然而,我发现用基本上相同设计和结构的装置产生的电动势超过前面提到的三四倍并没有困难,而且我已经确定电流脉冲可以通过密度大得多的空气层传输。通过使用这些,我还发现在不与发射和接收终端直接接触,而是远离它们,通过空气层传输大量能量是可行的。这些脉冲的作用,在通常表现得像一种绝缘体的密度的空气中延伸到一个相当远的距离,这种密度的空气呈现出传导性,如前所述。可以看出,在前面的例子中,在线圈或导体 A 的终端处获得的高电动势与其说是由于大的转换比,不如说是由于同步电路中的电容和电感的联合效应,该效应通过高频而增强,并且明显可以理解的是,如果后者被减小,则应该采用更大的转换比,特别是在认为是有利的情况下尽可能多地抑制,尤其是在发射线圈 A 中,这是由于上述效应,并且仅通过大的转换比就可以获得必要的电动势。

While electromotive forces such as are produced by the apparatus just described may be sufficient for many purposes to which my system will or may be applied, I wish to state that I contemplate using in

an industrial undertaking of this kind forces greatly in excess of these, and with my present knowledge and experience in this novel field I would estimate them to range from twenty to fifty million volts and possibly more. By the use of these much greater forces larger amount of energy may be conveyed through the atmosphere to remote places or regions, and the distance of transmission may be thus extended practically without limit.

虽然由刚才描述的装置产生的电动势对于我的系统将要或可能应用的许多目的来说可能是足够的，但是我希望声明，我打算在这种工业企业中使用远远超过这些的电动势，并且以我目前在这个新领域的知识和经验，我估计它们的范围从 2000 万伏到 5000 万伏，可能更大。通过使用这些大得多的电动势，大量的能量可以通过大气传输到偏远的地方或地区，因此传输距离实际上可以无限制地延长。

As to the elevation of the terminals D D' it is obvious that it will be determined by a number of things, as by the amount and quality of the work to be performed, by the local density and other conditions of the atmosphere, by the character of the surrounding country, and such considerations as may present themselves in individual instances. Thus if there be high mountains in the vicinity the terminals should be at a greater height, and generally they should always be, if practicable, at altitudes much greater than those of the highest objects near them in order to avoid as much as possible the loss by leakage. In some cases when small amounts of energy are required the high elevation of the terminal, and more particularly of the receiving-terminal D', may not be necessary, since, especially when the frequency of the currents is very high, a sufficient amount of energy may be collected at that terminal by electrostatic induction from the upper air strata, which are rendered conducting by active terminal of the transmitter or through which the currents from the same are conveyed.

至于终端 DD' 的高度，很明显，这将由许多因素决定，如要进行的工作的数量和质量、当地的密度和大气的其他条件、周围地区的特点、以及在个别情况下可能出现的考虑因素。因此，如果附近有高山，终端应处于一个较高的高度，如果可行，一般应始终处于比附近最高物体高得多的高度，以尽可能避免泄漏造成的损失。在一些情况下，当需要少量能量时，终端的高架，更具体地说，接收终端 D' 的高架可能不是必需的，因为，特别是当电流的频率非常高时，足够量的能量可以通过来自较上空气层的静电感应在该终端处被收集，该较上空气层被发射器的活跃终端赋予可传导性，或者通过较上空气层传送来自发射器的电流。

With reference to the facts which have been pointed out above it will be seen that the altitudes required for the transmission of considerable amounts of electrical energy in accordance with this method are such as are easily accessible and at which terminals can be safely maintained, as by the aid of captive balloons supplied continuously with gas from reservoirs and held in position securely by steel wires or by any other means, devices, or expedients, such as may be contrived and perfected by ingenious and skilled engineers. From my experiments and observations I conclude that with electromotive impulses not greatly exceeding fifteen or twenty million volts the energy of many thousands of horse-power may be transmitted over vast distances, measured by many hundreds and even thousands of miles, with terminals not more than thirty to thirty-five thousand feet above the level of the sea, and even this comparatively-small elevation will be required chiefly for reasons of economy, and, if desired, it may be considerably reduced, since by such means as have been described practically any potential that is desired may be obtained, the currents through the air strata may be rendered very small, whereby the loss in the transmission may be reduced.

参考上面已经指出的事实,可以看出,根据这种方法传输大量电能所需的高度是容易达到的,并且终端可以安全地保持在该高度,例如借助从储气器连续供应气体的气球以及通过钢丝或任何其他工具、装置或权宜之计牢固地把系留气球保持在适当位置,这可以由聪明和熟练的工程师设计和完善。从我的实验和观察中,我得出结论,用不是大大超过 1500 万伏或 2000 万伏的电动脉冲,几千匹马力的能量可以传输到很远的地方,测量到的距离几百英里甚至几千英里,终端不超过海平面以上 30000 英尺到 35000 英尺,甚至这个相对较小的高度也将需要,主要是为了经济,如果需要,这个高度可以大大减少,因为通过已经描述的这种工具,实际上可以获得任何期望的电势,所以通过空气层的电流可以变得非常小,由此可以减少传输中的损耗。

It will be understood that the transmitting as well as the receiving coils, transformers, or other apparatus may be in some cases movable—as, for example, when they are carried by vessels floating in the air or by ships at sea. In such a case, or generally, the connection of one of the terminals of the high-tension coil or coils to the ground may not be permanent, but may be intermittently or inductively established, and any such or similar modifications I shall consider as within the scope of my invention.

应当理解,发射线圈以及接收线圈、变压器或其他装置在某些情况下可以是可移动的,例如,当它们由漂浮在空中的飞艇或海上的船只运载时。在这种情况下,或者一般来说,高压线圈的一个或多个终端到达地面的连接可以不是永久性的,而是可以间歇地或感应地建立,并且任何这种或类似的修改将被认为在我的发明范围内。

While the description here given contemplates chiefly a method and system of energy transmission to a distance through the natural media for industrial purposes, the principles which I have herein disclosed and the apparatus which I have shown will obviously have many other valuable uses—as, for instance, when it is desired to transmit intelligible messages to great distances, or to illuminate upper strata of air, or to produce, designedly, any useful changes in the condition of the atmosphere, or to manufacture from the gases of the same products, as nitric acid, fertilizing compounds, or the like, by the action of such current impulses, for all of which and for many other valuable purposes they are eminently suitable, and I do not wish to limit myself in this respect. Obviously, also, certain features of my invention here disclosed will be useful as disconnected from the method itself—as, for example, in other systems of energy transmission, for whatever purpose they may be intended, the transmitting and receiving transformers arranged and connected as illustrated, the feature of a transmitting and receiving coil or conductor, both connected to the ground and to an elevated terminal and adjusted so as to vibrate in synchronism, the proportioning of such conductors or coils, as above specified, the feature of a receiving-transformer with its primary connected to earth and to an elevated terminal and having the operative devices in its secondary, and other features or particulars, such as have been described in this specification or will readily suggest themselves by a perusal of the same.

虽然这里给出的描述主要考虑了通过自然媒介将能量传输到一定距离的一种方法和系统,用于工业目的,但是我在此公开的原理和我展示的设备显然将具有许多其他有价值的用途——例如,当希望将可理解的信息传输到很远的距离,或者照亮空气的上层,或者有意地产生大气条件的任何有用的变化,或者通过这种电流脉冲的作用,由相同气体产品进行制造,如硝酸、肥料等,对于所有这些和许多其他有价值的目的,它们都非常适合,我不想在这方面限制自己。一个发射和接收线圈或导体的特征,都是连接到接地并并且连接到高架终端并被调整,目的是同步振动,这样的导体或线圈的比例分配,如上所述,接收变压器的特征,其初

级连接到接地和一个高架终端，并且在其次级中具有操作装置，以及其它特征或细节，如在本说明书中已经描述的或通过细读本说明书将很容易想到的。

I do not claim in this application a transformer for developing or converting currents of high potential in the form herewith shown and described and with the two coils connected together, as and for the purpose set forth, having made these improvement the subject of a patent granted to me November 2, 1897, No. 593,138, nor do I claim herein the apparatus employed in carrying out the method of this application when such apparatus is specially constructed and arranged for securing the particular object sought in the present invention, as these last-named features are made the subject of an application filed as a division of this application on February 19, 1900, Serial No. 5,780.

在本申请书中，我没有主张用于开发或转换高电位电流的变压器，该变压器具有在此展示和描述的形式，并且具有连接在一起的两个线圈，并且为了所述的目的，已经使这些改进成为在 1897 年 11 月 2 日授予我的第 593,138 号专利的主题，当这种装置被特别构造和布置用于保护本发明中所寻找的特定对象时，我在此也不主张在实施本申请的方法时所使用的装置，因为这些最后提到的特点是在 1900 年 2 月 19 日提交的序列号为 5,780 的申请的分案的主题。

What I now claim is—

现在我主张的是—

1. The method hereinbefore described of transmitting electrical energy through the natural media, which consists in producing at a generating-station a very high electrical pressure, causing thereby a propagation or flow of electrical energy, by conduction, through the earth and the air strata, and collecting or receiving at a distant point the electrical energy so propagated or caused to flow.

1、上文所述的通过自然媒介传输电能的方法，包括在发电站产生非常高的电压力，从而通过传导使电能在大地和空气层中传播或流动，并在远处收集或接收如此传播或流动的电能。

2. The method hereinbefore described of transmitting electrical energy, which consist in producing at a generating-station a very high electrical pressure, conducting the current caused thereby to earth and to a terminal at an elevation at which the atmosphere serves as a conductor therefor, and collecting the current by a second elevated terminal at a distance from the first.

2、上文描述的传输电能的方法包括在发电站产生非常高的电压力，将由此产生的电流传导到地面和海拔高度处的一个终端，在该处大气作为导体，并通过与第一终端相距一定距离的第二高架终端收集电流。

3. The method hereinbefore described of transmitting electrical energy through the natural media, which consists in producing between the earth and a generator-terminal elevated above the same, at a generating-station, a sufficiently-high electromotive force to render elevated air strata conducting, causing thereby a propagation or flow of electrical energy, by conduction, through the air strata, and collecting or receiving at a point distant from the generating-station the electrical energy so propagated or caused to flow.

3、上述的通过自然媒介传输电能的方法，包括在发电站的地面和高于地面的发电机终端之间产生一个足够高的电压，使高空的空气层导电，从而使电能通过空气层传播或流动，并在距离发电站很远的地方收集或接收这样传播或流动的电能。

4. The method hereinbefore described of transmitting electrical energy through the natural media, which consists in producing between the earth and a generator-terminal elevated above the same, at a generating-station, a sufficiently-high electromotive force to render the air strata at or near the elevated terminal conducting, causing thereby a propagation or flow of electrical energy, by conduction, through the air strata, and collecting or receiving at a point distant from the generating-station the electrical energy so propagated or caused to flow.

4、上文所述的通过自然媒介传输电能的方法，包括在发电站的地面和位于地面上方的一个发电机终端之间产生足够高的电动势，以使在高架终端处或附近的空气层导电，从而通过导电使电能通过空气层传播或流动，并在远离发电站的一个位置收集或接收如此传播或流动的电能。

5. The method hereinbefore described of transmitting electrical energy through the natural media, which consists in producing between the earth and a generator-terminal elevated above the same, at a generating-station, electrical impulses of a sufficiently-high electromotive force to render elevated air strata conducting, causing thereby current impulses to pass, by conduction, through the air strata, and collecting or receiving at a point distant from the generating-station, the energy of the current impulses by means of a circuit synchronized with the impulses.

5、上文所述的通过自然媒介传输电能的方法，包括在发电站的地面和高于地面的发电机终端之间产生足够高电压的电脉冲，使高空空气层导电，从而使电流脉冲利用传导通过空气层，并通过与脉冲同步的一个电路在远离发电站的一个位置收集或接收电流脉冲的能量。

6. The method hereinbefore described of transmitting electrical energy through the natural media, which consists in producing between the earth and a generator-terminal elevated above the same, at a generating-station, electrical impulses of a sufficiently-high electromotive force to render the air strata at or near the elevated terminal conducting, causing thereby current impulses to pass through the air strata, and collecting or receiving at a point distant from the generating-station the energy of the current impulses by means of a circuit synchronized with the impulses.

6、上述的通过自然媒介传输电能的方法，包括在发电站的地面和高于地面的发电机终端之间产生足够高的电压的电脉冲，使位于高架终端或者接近高架终端的空气导电，从而使电流脉冲通过空气层传导，通过使用与脉冲同步的电路，在远离发电站的位置收集或接收电能。

7. The method hereinbefore described of transmitting electrical energy through the natural media, which consists in producing between the earth and a generator-terminal elevated above the same, at a generating-station, electrical impulses of a wave length so related to the length of the generating circuit or conductor as to produce the maximum potential at the elevated terminal, and of sufficiently-high electromotive force to render elevated air strata conducting, causing thereby a propagation of electrical impulses through the air strata, and collecting or receiving at a point distant from the generating-station the energy of such impulses by means of a receiving-circuit having a length of conductor similarly

related to the wave length of the impulses.

7、上述的通过自然媒介传输电能的方法，包括在发电站的地面和高于地面的发电机终端之间产生与发电电路或导体长度相关波长的电脉冲，以便在高架终端产生最大电势，并产生足够高的电压，使高空空气层导电，从而导致电脉冲通过空气层传播，并利用具有与波长相似的导体长度的一个接收电路，在远离发电站的位置收集或接收来这种电脉冲的能量。

8. The method hereinbefore described of transmitting electrical energy through the natural media, which consists in producing between the earth and a generator-terminal elevated above the same, at a generating-station, a sufficiently-high electromotive force to render elevated air strata conducting, causing thereby a propagation or flow of electrical energy through the air strata, by conduction, collecting or receiving the energy so transmitted by means of a receiving-circuit at a point distant from the generating-station, using the receiving-circuit to energize a secondary circuit, and operating translating devices by means of the energy so obtained in the secondary circuit.

8、上文所述的通过自然媒介传输电能的方法，包括在发电站的地面和高于地面的发电机终端之间产生足够高的电动势，以使高空的空气层导电，从而导致电能通过空气层传播或流动，通过远离发电站的接收电路收集或接收如此传输的能量，是使用接收电路激励一个次级电路，并通过在次级电路中如此获得的能量操作转换装置。

9. The method hereinbefore described of transmitting electrical energy through the natural media, which consists in generating current impulses of relatively-low electromotive force at a generating-station, utilizing such impulses to energize the primary of a transformer, generating by means of such primary circuit impulses in a secondary surrounding by the primary and connected to the earth and to an elevated terminal, of sufficiently-high electromotive force to render elevated air strata conducting, causing thereby impulses to be propagated through the air strata, collecting or receiving the energy of such impulses, at a point distant from the generating-station, by means of a receiving-circuit connected to the earth and to an elevated terminal, and utilizing the energy so received to energize a secondary circuit of low potential surrounding the receiving-circuit.

9、上文所述的通过自然媒介传输电能的方法，包括在发电站产生电动势相对较低的电流脉冲，利用这种脉冲给变压器的初级线圈供电，在初级线圈周围的次级线圈中利用这种初级电路脉冲产生足够高的电动势，使高空的空气层导电，从而使脉冲通过空气层传播，利用连接到接地和高架终端的接收电路，在远离发电站的地方收集或接收这种脉冲的能量，并利用这样接收的能量激励接收电路周围的低电位次级电路。

NIKOLA TESLA
尼古拉·特斯拉

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No. 645,576.

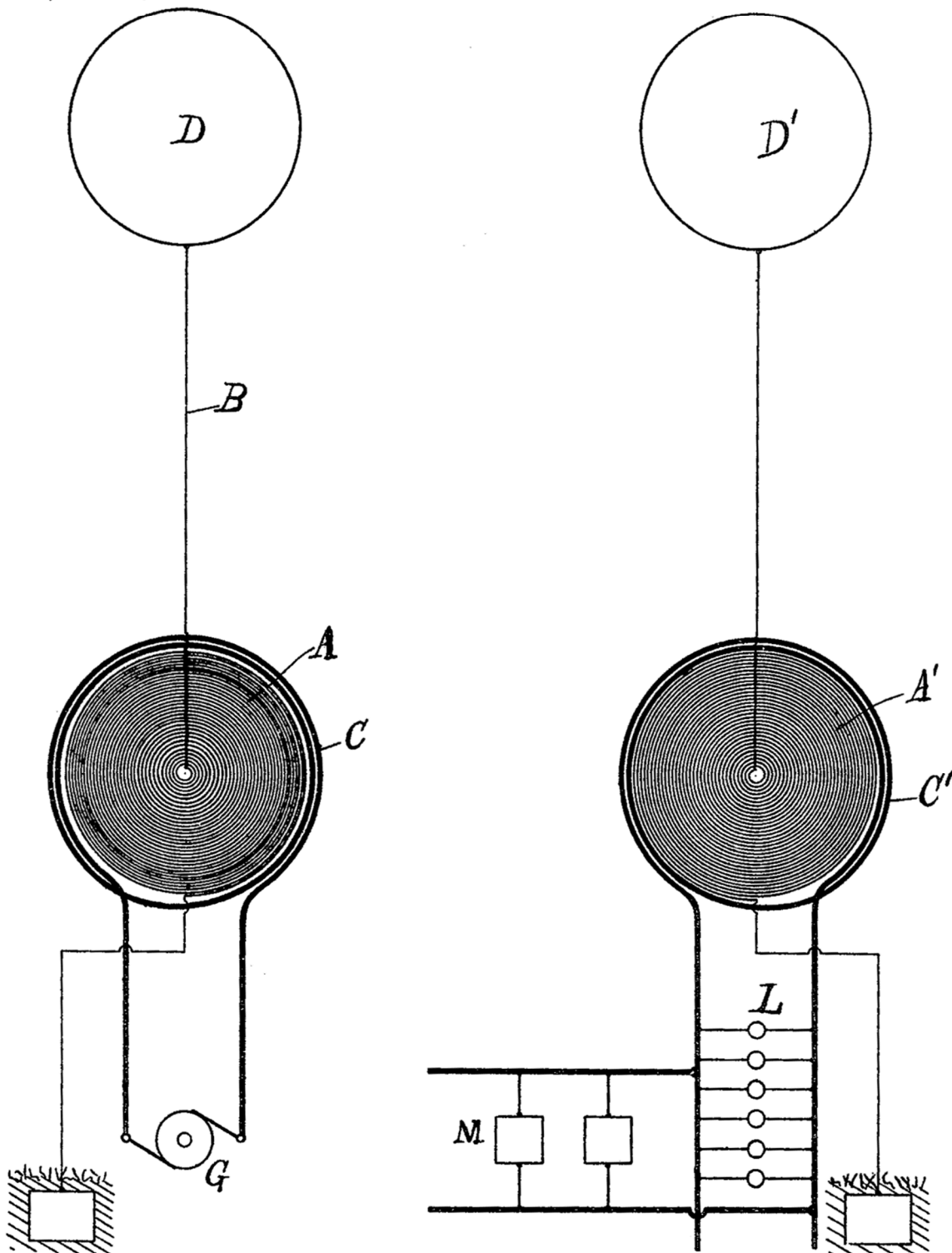
Patented Mar. 20, 1900.

N. TESLA.

SYSTEM OF TRANSMISSION OF ELECTRICAL ENERGY.

(Application filed Sept. 2, 1897.)

(No Model.)



WITNESSES

Dwight N. Cooper
M. Ramsden

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Nikola Tesla
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ATTORNEYS.

APPARATUS FOR TRANSMISSION OF ELECTRICAL ENERGY

用于电能传输的装置

NIKOLA TESLA, OF NEW YORK, N. Y.

纽约州纽约市的尼古拉·特斯拉

SPECIFICATION forming part of Letters Patent No. 649,621, dated March 15, 1900.

Original application filed September 2, 1897, Serial No. 650,343.

Divided and this application filed February 19, 1900. Serial No. 5,780. (No model.)

该说明书形成了颁发于1900年3月15日编号为649,621的专利证书的一部分。

原始申请于1897年9月2日提交，序列号650,343。

1900年2月19日原始申请被分立并且该申请被提交。序列号5,780。(没有模型)

To all whom it may concern:

致所有相关人士:

Be it known that I, NIKOLA TESLA, a citizen of the United States, residing at the borough of Manhattan, in the city of New York country and State of New York, have invented certain new and useful Improvements in Apparatus for the Transmission of Electrical Energy, of which the following is a specification, reference being had to the drawing accompanying and forming a part of the same.

众所周知，我、尼古拉·特斯拉、一位美国公民，居住在纽约州纽约郡纽约市的曼哈顿区，在电能传输装置方面发明了某些新的有用的改进，以下是该发明一个说明，必须参考随附的图纸，它已形成该说明书的一部分。

This application is a division of an application filed by me on September 2, 1897, Serial No. 650,343, entitled "Systems of transmissions of electrical energy," and is based upon new and useful features and combinations of apparatus shown and described in said application for carrying out the method therein disclosed and claimed.

本申请是我于1897年9月2日提交的申请的一部分，申请号为650,343，标题为《电能传输系统》，并且基于在所述申请中展示和描述的装置的新的和有用的特征和组合，用于执行其中公开和主张的方法。

The invention which forms the subject of my present application comprises a transmitting coil or conductor in which electrical currents or oscillations are produced and which is arranged to cause such currents or oscillations to be propagated by conduction through the natural medium from one point to another remote there from and a receiving coil or conductor at such distant point adapted to be excited by the oscillations or currents propagated from the transmitter.

构成本申请主题的本发明包括发射线圈或导体，其中产生电流或振荡，并被布置成通过传导使这种电流或振荡通过自然媒介从一个位置传播到远离该位置的另一个位置，以及在这种遥远位置的接收线圈或导体，它们适于被发射器传播的振荡或电流所激励。

This apparatus is shown in the accompanying drawing, which is a diagrammatic illustration of the same. A is a coil, generally of many turns and of a very large diameter, wound in spiral form either about a magnetic core or not, as may be desired. C is a second coil formed by a conductor of much larger size and smaller length wound around and in proximity to the coil A.

这个装置显示在附图中，这是这个装置的一个图解说明。A 是一个线圈，通常有许多匝，直径很大，绕成螺旋形，或者绕在磁芯上，或者不绕在磁芯上。C 是由更大尺寸和更小长度的导体缠绕并靠近线圈 A 形成的第二线圈。

The apparatus at one point is used as a transmitter, the coil A in this case constituting a high-tension, secondary, and the coil C the primary, of much lower tension, of a transformer. In the circuit of the primary C is included a suitable source of current G. One terminal of the secondary A is at the center of the spiral coil, and from this terminal the current is led by a conductor B to a terminal D, preferably of large surface, formed or maintained by such means as a balloon at an elevation suitable for the purposes of transmission. The other terminal of the secondary A is connected to earth, and, if desired, to the primary also, in order that the latter maybe at substantially the same potential as the adjacent portions of the secondary, thus insuring safety. At the receiving-station a transformer of similar construction is employed; but in this case the longer coil A' constitutes the primary, and the shorter coil C' the secondary, of the transformer. In the circuit of the latter are connected lamps L, motors M, or other devices for utilizing the current. The elevated terminal D' connects with the center of the coil A', and the other terminal of said coil is connected to earth and preferably, also, to the coil C' for the reasons above stated.

该设备在某一地点上被用作发送器，在这种情况下，线圈 A 被看作变压器的一个高压次级线圈，线圈 C 构成变压器的电压低得多的初级线圈。初级 C 的电路中包含一个合适的电流源 G。次级线圈 A 的一个终端位于螺旋线圈的中心，并且电流从该终端由导体 B 引导至终端 D，终端 D 优选具有大的表面，由诸如气球的工具形成或保持在适于传输目的的高度。次级线圈 A 的另一个终端接地，并且如果需要，还连接到初级，以便初级可以与次级的相邻部分处于基本相同的电位，从而确保安全。在接收站，采用类似结构的变压器；但是在这种情况下，较长的线圈 A' 构成变压器的初级线圈，较短的线圈 C' 构成变压器的次级线圈。后者的电路中连接有灯 L、电动机 M 或其他利用电流的装置。架高的终端 D' 与线圈 A' 的中心连接，并且所述线圈的另一个终端接地，并且出于上述原因，也首选连接到线圈 C' 上。

The length of the thin wire coil in each transformer should be approximately one quarter of the wave length of the electric disturbance in the circuit, this estimate being based on the velocity of propagation of the disturbance through the coil itself and the circuit with which it is designed to be used. By way of illustration, if the rate at which the current traverses the circuit including the coil be one hundred and eighty five thousand miles per second then a frequency of nine hundred and twenty-five per second would maintain nine hundred and twenty-five stationary waves in a circuit one hundred and eighty-five thousand miles long and each wave would be two hundred miles in length.

每个变压器中细导线线圈的长度应该大约是电路中电扰动波长的四分之一,这个估计值是基于扰动通过线圈本身和电路的传播速度。举例来说,如果电流通过包括线圈的电路的速率是每秒 185,000 英里,那么每秒 925 的频率将在 185,000 英里长的电路中保持 925 个驻波,并且每个波的长度将是 200 英里。

For such a low frequency, which would be resorted to only when it is indispensable for the operation of motors of the ordinary kind under the conditions above assumed, I would use a secondary of fifty miles in length. By such an adjustment or proportioning of the length of wire in the secondary coil or coils the points of highest potential are made to coincide with the elevated terminals D D', and it should be understood that whatever length be given to the wires this requirement should be complied with in order to obtain the best results.

对于如此低的频率,只有在上述假设条件下普通类型的电动机运行不可或缺时才会采用,我将使用 50 英里长的一个次级线圈。通过对次级线圈中的导线长度进行这种比例分配,使最高电位点与架高的终端 D D'重合,应该理解,无论导线的长度是多少,都应该符合这一要求,以获得最佳结果。

It will be readily understood that when the above-prescribed relations exist the best conditions for resonance between the transmitting and receiving circuits are attained, and owing to the fact that the points of highest potential in the coils or conductors A A' are coincident with the elevated terminals the maximum flow of current will take place in the two coils, and this, further, necessarily implies that the capacity and inductance in each of the circuits have such values as to secure the most perfect condition of synchronism with the impressed oscillations.

很容易理解的是,当上述关系存在时,获得了发射电路和接收电路之间的最佳谐振条件,并且由于线圈或导体 A A'中的最高电位点与高架终端重合,最大电流将在两个线圈中发生,并且这进一步必然意味着每个电路中的电容和电感具有这样的值,以确保与外加振荡同步的最佳条件。

When the source of current G is in operation and produces rapidly pulsating or oscillating currents in the circuit of coil C, corresponding induced currents of very much higher potential are generated in the secondary coil A, and since the potential in the same gradually increases with the number of turns toward the center and the difference of potential between the adjacent turns is comparatively small a very high potential impracticable with ordinary coils may be successively obtained.

当电流源 G 运行并在线圈 C 的电路中产生快速脉动或振荡电流时,在次级线圈 A 中产生相应的高得多的感应电流,并且由于次级线圈 A 中的电势随着指向中心的匝数的增加而逐渐增加,并且相邻匝之间的电势差相对较小,所以可以连续获得普通线圈无法实现的高电势。

As the main object for which the apparatus is designed is to produce a current of excessively high potential, this object is facilitated by using a primary current of very considerable frequency; but the frequency of the currents is in a large measure arbitrary, for if the potential be sufficiently high and the terminals of the coils be maintained at the proper elevation where the atmosphere is rarefied the stratum of air will serve as a conducting medium for the current produced and the latter will be transmitted through the air, with, it may be, even less resistance than through an ordinary conductor.

由于该装置设计的主要目的是产生过高电势的电流,因此通过使用相当大频率的初级电流来实现该目的;但是电流的频率在很大程度上是随意的,因为如果电势足够高,并且线圈的终端保持在适当的高度,在该高度,大气变得稀薄,空气层将作为产生的电流的传导媒介,并且产生的电流将通过空气传输,这时空气电阻可能比通过普通导体更小。

As to the elevation of the terminals D D', it is obvious that this is a matter which will be determined by a number of things, as by the amount and quality of the work to be performed, by the condition of the atmosphere, and also by the character of the surrounding country. Thus if there be high mountains in the vicinity the terminals should be at a greater height, and generally they should always be at an altitude much greater than that of the highest objects near them. Since by the means described practically any potential that is desired may be produced, the currents through the air strata may be very small, thus reducing the loss in the air.

至于终端 D D'的高度,显然这是一个由许多因素决定的问题,例如要进行的工作的数量和质量、大气条件以及周围环境的特点。因此,如果附近有高山,终端应该在一个更高的高度,一般来说,它们应该总是在一个比附近最高物体高得多的高度。由于利用所描述的工具,实际上可以产生任何期望的电势,所以通过空气层的电流可以非常小,从而减少空气中的损失。

The apparatus at the receiving-station responds to the currents propagated from the transmitter in a manner which will be well understood from the foregoing description. The primary circuit of the receiver—that is, the thin wire coil A'—is excited by the currents propagated by conduction through the intervening natural medium from the transmitter, and these currents induce in the secondary coil C' other currents which are utilized for operating the devices included in the circuit thereof.

接收站的设备以从前面的描述可以很好理解的方式响应从发射机传播的电流。接收器的初级电路,即细线圈 A', 也就是细导线线圈,被从发射器通过介入之间的自然媒介传导传播的电流所激励,并且这些电流在次级线圈 C' 中感应出其它电流,这些电流被用于操作被包含在其电路中的设备。

Obviously the receiving coils, transformers, or other apparatus may be movable — as, for instance, when they are carried by a vessel floating in the air or by a ship at sea. In the former case the connection of one terminal of the receiving apparatus to the ground might not be permanent, but might be intermittently or inductively established without departing from the spirit of my invention.

显然,接收线圈、变压器或其他设备可以移动的——例如,当它们由漂浮在空中的飞艇或海上的船只携带时。在前一种情况下,接收设备的一个终端与地面的连接可以不是永久的,但可以是间歇性或感应地建立起来,这并不背离我的该发明的精神。

It is to be noted that the phenomenon here involved in the transmission of electrical energy is one of true conduction and is not to be confounded with the phenomena of electrical radiation which have heretofore been observed and which from the very nature and mode of propagation would render practically impossible the transmission of any appreciable amount of energy to such distances as are of practical importance.

需要注意的是,电能传输所涉及的现象是一种真正的传导现象,并且不会与迄今为止已经观

察到的电辐射现象相混淆，因为从传播的性质和方式来看，电磁辐射几乎不可能将任何可观的能量传输到实际上具有重要意义距离。

What I now claim as my invention is—

我现在主张我的发明是：

1. The combination with a transmitting coil or conductor connected to ground and to an elevated terminal respectively, and means for producing therein electrical currents or oscillations, of a receiving coil or conductor similarly connected to ground and to an elevated terminal, at a distance from the transmitting-coil and adapted to be excited by currents caused to be propagated from the same by conduction through the intervening natural medium, a secondary conductor in inductive relation to the receiving-conductor and devices for utilizing the current in the circuit of said secondary conductor, as set forth.

1、一种组合，它包括分别连接到接地和高架终端的一个发射线圈或导体，以及用于在其中产生电流或振荡的工具；在距离发射线圈一定距离处类似地连接到接地和高架终端的一个接收线圈或导体并适于由介入之间自然媒介传导的从发射线圈或导体传播出来的电流所激励；与接收导体成感应关系的一个次级导体和用于利用所述次级导体电路中的电流的装置，如上所述。

2. The combination with a transmitting coil or conductor having its ends connected to ground and to an elevated terminal respectively, a primary coil in inductive relation thereto and a source of electrical oscillations in said primary circuit, of a receiving conductor or coil having its ends connected to ground and to an elevated terminal respectively and adapted to be excited by currents caused to be propagated from the transmitter through the natural medium and a secondary circuit in inductive relation to the receiving circuit and receiving devices connected therewith, as set forth.

2、一种组合，它包括分别连接到接地和高架终端的一个发射线圈或导体；一个与其有感应关系的初级线圈和所述初级电路中的电振荡源；分别连接到接地和高架终端的一个接收线圈或导体，并适于由中间自然媒介传导的从发射线圈或导体传播出来的电流所激励；以及与接收电路和与其连接的接收设备成感应关系的次级电路，如上所述。

3. The combination with a transmitting instrument comprising a transformer having its secondary connected to ground and to an elevated terminal respectively, and means for impressing electrical oscillations upon its primary, of a receiving instrument comprising a transformer having its primary similarly connected to ground and to an elevated terminal, and a translating device connected with its secondary, the capacity and inductance of the two transformers having such values as to secure synchronism with the impressed oscillations, as set forth.

3、一种组合，它包括一种发射装置，该发射装置包括次级分别与地面和高架终端连接的变压器，以及该发射装置在此变压器初级上施加电振荡的工具；一种接收装置包括初级与接地和高架终端类似连接的变压器，以及与该变压器次级连接的转换装置；两个变压器的电容量和电感具有能确保与外加振荡同步的值，如前所述。

4. The combination with a transmitting instrument comprising an electrical transformer having its secondary connected to ground and to an elevated terminal respectively, and means for impressing electrical oscillations upon its primary, of a receiving instrument comprising a transformer having its primary similarly connected to ground and to an elevated terminal, and a translating device connected with its secondary, the capacity and inductance of the secondary of the transmitting and primary of the receiving instruments having such values as to secure synchronism with the impressed oscillations, as set forth.

4、一种组合，它包括一种发射装置，该发射装置包括次级分别与接地和高架终端连接的变压器，以及该发射装置在此变压器初级电路上施加电振荡的工具；一种接收装置包括初级与接地和高架终端有着相似连接的变压器，以及与该变压器次级终端连接的转换装置；发射装置的次级和接收装置的初级的电容和电感具有能确保与外加振荡同步的值，如前所述。

5. The combination with a transmitting coil or conductor connected to ground and an elevated terminal respectively, and means for producing electrical currents or oscillations in the same, of a receiving coil or conductor similarly connected to ground and to an elevated terminal and synchronized with the transmitting coil or conductor, as set forth.

5、一种组合，它包括分别连接到接地和高架终端的一个发射线圈或导体，以及在同样的电路中产生电流或振荡的工具；与接地和高架终端采用类似连接的方法的一个接收线圈或导体，并与发射线圈或导体同步，如前所述。

6. The combination with a transmitting instrument comprising an electrical transformer, having its secondary connected to ground and to an elevated terminal respectively, of a receiving instrument comprising a transformer, having its primary similarly connected to ground and to an elevated terminal, the receiving-coil being synchronized with that of the transmitter, as set forth.

6、一种组合，它包括一种发射装置，由一个电力变压器构成，其次级分别连接到接地和高架终端；一种接收装置，由一个电力变压器构成，其初级类似连接到接地和高架终端，接收线圈与发射线圈同步，如前所述。

7. The combination with a transmitting coil or conductor connected to ground and to an elevated terminal respectively, and means for producing electrical currents or oscillations in the same, of a receiving coil or conductor similarly connected to ground and to an elevated terminal, the said coil or coils having a length equal to one quarter of the wave length of the disturbance propagated, as set forth.

7. 一种组合，它包括分别连接到接地和高架终端的一个发射线圈或导体；以及在该发射线圈中产生电流和电振荡的工具；以类似方式连接到接地和高架终端的一个接收线圈或导体，所述线圈或多个线圈，其自身的长度等于被传播的电扰动波长的四分之一，如前所述。

8. The combination with a transmitting coil or conductor connected to ground and to an elevated terminal respectively, and adapted to cause the propagation of currents or oscillations by conduction through the natural medium, of a receiving-circuit similarly connected to ground and to an elevated terminal, and of a capacity and inductance such that its period of vibration is the same as that of the transmitter, as set forth.

8、一种组合，它包括一个分别连接到接地和高架终端的发射线圈或导体；该发射线圈或导体适于引起能通过自然媒介来传导的电流或振荡的传播；与接地和高架终端类似连接的接收电路；以及一个容量和电感，使其振动周期与发射器的振动周期相同，如前所述。

9. The transmitting or receiving circuit herein described, connected to ground and an elevated terminal respectively, and arranged in such manner that the elevated terminal is charged to the maximum potential developed in the circuit, as set forth.

9、本文所述的发射电路或接收电路，分别连接到地面和高架终端，并且布置方式使高架终端被充电到最高电位，如前所述。

10. The combination with a transmitting coil or conductor connected to ground and to an elevated terminal respectively of a receiving-circuit having a period of vibration corresponding to that of the transmitting-circuit and similarly connected to ground and to an elevated terminal and so arranged that the elevated terminal is charged to the highest potential developed in the circuit, as set forth.

10、一种组合，它包括分别连接到接地和高架终端的一个发射线圈或导体；接收电路具有与发射电路相一致的振动周期，并与接地和高架终端相类似地连接，这样布置以便将高架终端充电到电路中的最高电位，如前所述。

NIKOLA TESLA.

尼古拉·特斯拉

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见证人：

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No. 649,621.

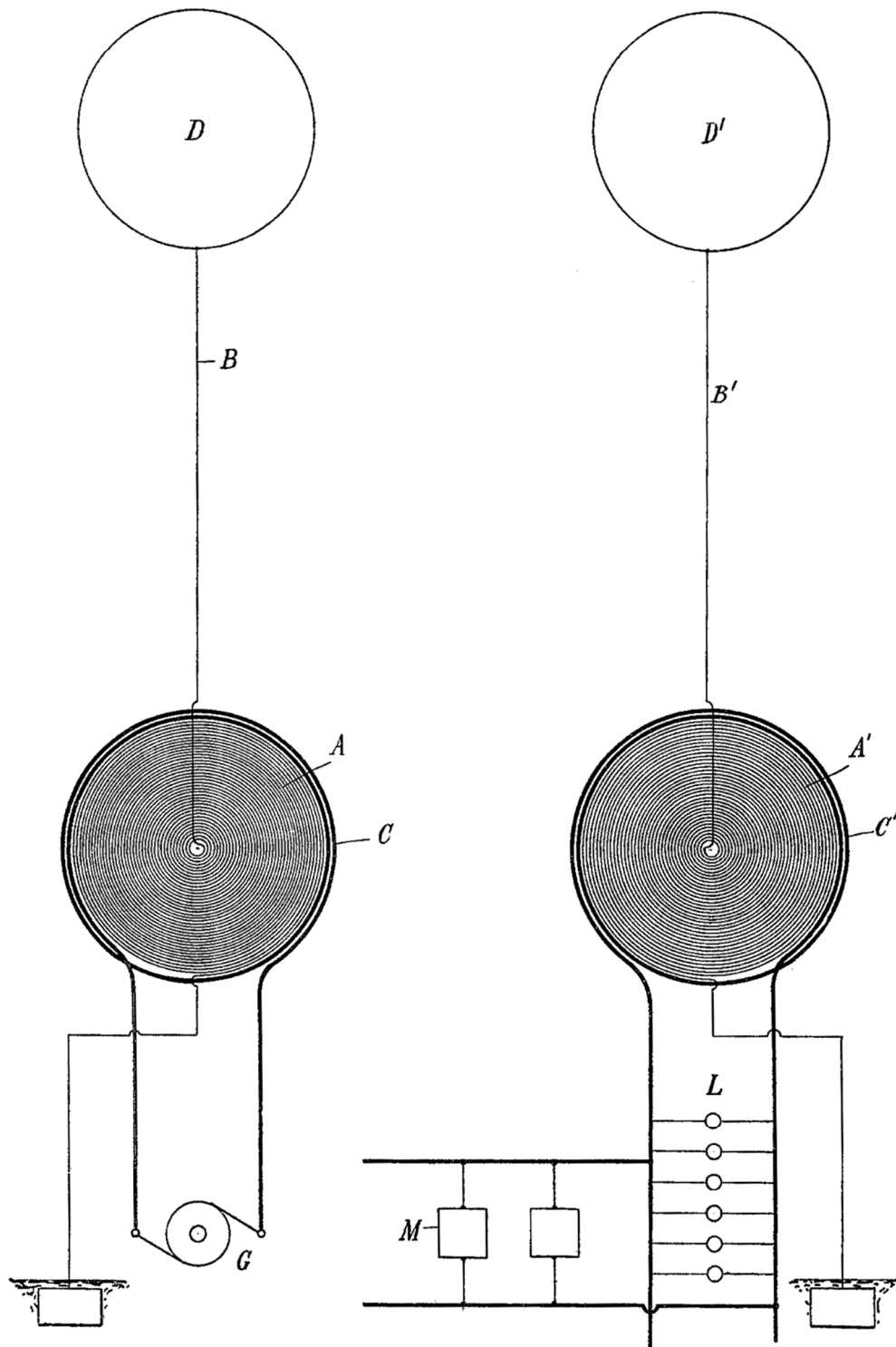
Patented May 15, 1900.

N. TESLA.

APPARATUS FOR TRANSMISSION OF ELECTRICAL ENERGY.

(Application filed Feb. 19, 1900.)

(No Model.)



Witnesses:
Bryan Miller.
G. W. Marling.

Nikola Tesla, Inventor
by *Ken. Page & Co.* Attys

MEANS FOR INCREASING THE INTENSITY OF ELECTRICAL OSCILLATIONS.

用于增加电振荡强度的工具

NIKOLA TESLA, OF NEW YORK, N. Y.

纽约州纽约市的尼古拉·特斯拉

SPECIFICATION forming part of Letters Patent No. 685,012, dated October 22, 1901.

Application filed March 21, 1900. Renewed July 3, 1901. Serial No. 66,980. (No model.)

该说明书形成了颁发于 1901 年 10 月 22 日编号为 685,012 的专利证书的一部分。

申请于 1900 年 3 月 21 日提交。序列号 66,980。(没有模型)

To all whom it may concern:

致所有相关人士:

Be it known that I, NIKOLA TESLA, a citizen of the United States, residing at the borough of Manhattan, in the city, county, and State of New York, have invented certain new and useful Improvements in Means for Increasing the Intensity of Electrical Oscillations, of which the following is a specification, reference being had to the drawings accompanying and forming part of the same.

众所周知，我、尼古拉·特斯拉，一个美国公民，居住在纽约州纽约郡纽约市的曼哈顿区，在用于增加电振荡强度的工具方面已经发明了某些新的和有用的改进，以下是该发明一个说明书，必须参考随附的图纸，它已形成该说明书的一部分。

In many scientific and practical uses of electrical impulses or oscillations—as, for example, in systems of transmitting intelligence to distant points—it is of great importance to intensify as much as possible the current impulses or vibrations which are produced in the circuits of the transmitting and receiving instruments, particularly of the latter.

在电脉冲或振荡的许多科学和实际应用中——例如，在向远处传送情报的系统中——尽可能地增强在发射仪器和接收仪器的电路中产生的电流脉冲或振荡是非常重要的，尤其是在接收仪器的电路中。

It is well known that when electrical impulses are impressed upon a circuit adapted to oscillate freely the intensity of the oscillations developed in the same is dependent on the magnitude of its physical constants and the relation of the periods of the impressed and of the free oscillations. For the attainment of the best result it is necessary that the periods of the impressed should be the same as that of the free oscillations, under which conditions the intensity of the latter is greatest and chiefly dependent on the inductance and resistance of the circuit, being directly proportionate to the former and inversely to the

latter. In order, therefore, to intensify the impulses or oscillations excited in the circuit—in other words, to produce the greatest rise of current or electrical pressure in the same—it is desirable to make its inductance as large and its resistance as small as practicable. Having this end in view I have devised and used conductors of special forms and of relatively very large cross-section; but I have found that limitations exist in regard to the increase of the inductance as well as to the diminution of the resistance. This will be understood when it is borne in mind that the resonant rise of current or pressure in a freely-oscillating circuit is proportionate to the frequency of the impulses and that a large inductance in general involves a slow vibration. On the other hand, an increase of the section of the conductor with the object of reducing its resistance is, beyond a certain limit, of little or no value, principally because electrical oscillations, particularly those of high frequency, pass mainly through the superficial conducting layers, and while it is true that this drawback may be overcome in a measure by the employment of thin ribbons, tubes, or stranded cables, yet in practice other disadvantages arise, which often more than offset the gain.

众所周知,当电脉冲施加在一个适于自由振荡的电路上时,电路中产生的振荡强度取决于其物理常数的大小以及施加脉冲的周期和自由振荡周期的关系。为了获得最好的结果,有必要使得所施加的脉冲的周期与自由振荡的周期相同,在这种情况下,自由振荡的强度是最大的,主要取决于电路的电感和电阻,与前者成正比,与后者成反比。因此,为了加强电路中激发的脉冲或振荡,换句话说,为了在电路中产生最大的电流或电压上升,需要使其电感尽可能大,电阻尽可能小。考虑到这一点,我设计并使用了特殊形式的和横截面相对非常大的导体;但是我发现,在增加电感和减小电阻方面存在局限性。当记住在自由振荡电路中电流或压力的谐振上升与脉冲频率成正比,并且大电感通常涉及缓慢振动时,这一点就可以理解了。另一方面,为了降低导体的电阻而增加导体的截面,在超过一定限度时,几乎没有或没有价值,主要是因为电振荡,特别是高频的电振荡,主要通过表面的导电层,虽然这种缺点确实可以通过使用薄带、管或绞合电缆在一定程度上得到克服,但在实践中会出现其它缺点,这些缺点常常会抵消收益。

It is a well-established fact that as the temperature of a metallic conductor rises its electrical resistance increases, and in recognition of this constructors of commercial electrical apparatus have heretofore resorted to many expedients for preventing the coils and other parts of the same from becoming heated when in use, but merely with a view to economizing energy and reducing the cost of construction and operation of the apparatus.

众所周知,当金属导体的温度升高时,其电阻增加,并且认识到这一点,商用电气设备的制造者迄今为止采取了许多权宜之计来防止线圈和相同的其他部件在使用时变热,但是仅仅是为了节约能量和降低设备的构造和运行成本。

Now I have discovered that when a circuit adapted to vibrate freely is maintained at a low temperature the oscillations excited in the same are to an extraordinary degree magnified and prolonged, and I am thus enabled to produce many valuable results which have heretofore been wholly impracticable.

现在我发现,当一个适合自由振动的电路保持在低温下时,其中激发的振荡会在很大程度上放大和延长,因此我能够产生许多迄今为止完全不可行的有价值的结果。

Briefly stated, then, my invention consists in producing a great increase in the intensity and duration of

the oscillations excited in a freely-vibrating or resonating circuit by maintaining the same at a low temperature.

简而言之，我的发明在于通过将自由振荡电路或谐振电路保持在低温下，在该电路中激发的振荡的强度和持续的时间极大地增加和延长。

Ordinarily in commercial apparatus such provision is made only with the object of preventing wasteful heating, and in any event its influence upon the intensity of the oscillations is very slight and practically negligible, for as a rule impulses of arbitrary frequency are impressed upon a circuit, irrespective of its own free vibrations, and a resonant rise is expressly avoided.

通常，在商业设备中，这样的措施仅仅是为了防止无用的发热，并且在任何情况下，它对振荡强度的影响都是非常轻微的，实际上可以忽略不计，因为通常任意频率的脉冲被施加在电路上，与其自身的自由振动无关，并且明显避免了谐振上升。

My invention, it will be understood, does not primarily contemplate the saving of energy, but aims at the attainment of a distinctly novel and valuable result—that is, the increase to the greatest practicable degree of the intensity and duration of free oscillations. It may be usefully applied in all cases when this special object is sought, but offers exceptional advantages in those instances in which the freely-oscillating discharges of a condenser are utilized.

可以理解的是，我的发明并不主要考虑能量的节省，而是旨在获得一个独特的新颖的和有价值的结果——也就是说，将自由振荡的强度和持续时间增加到最大可行的程度。当寻求这种特殊目的时，它可以有效地应用于所有情况，但是在利用电容器的自由振荡放电的那些情况下提供了特别的优势。

The best and most convenient manner of carrying out the invention of which I am now aware is to surround the freely-vibrating circuit or conductor, which is to be maintained at a low temperature, with a suitable cooling medium, which may be any kind of freezing mixture or agent, such as liquid air, and in order to derive the fullest benefit from the improvement the circuit should be primarily constructed so as to have the greatest possible self-induction and the smallest practicable resistance, and other rules of construction which are now recognized should be observed. For example, when in a system of transmission of energy for any purpose through the natural media the transmitting and receiving conductors are connected to earth and to an insulated terminal, respectively, the lengths of these conductors should be one-quarter of the wave length of the disturbance propagated through them.

我现在所知道的实施本发明的最佳和最方便的方式是用合适的冷却介质包围要保持在低温下的自由振荡电路或导体，该冷却介质可以是任何种类的冷冻混合物或试剂，例如液态空气，并且为了从该改进中获得最大的益处，该电路应该主要构造成具有最大可能的自感和最小的实际电阻，并且应该遵守现在公认的其它构造规则。例如，在通过自然介质传输能量的系统中，当发射导体和接收导体分别接地和连接到绝缘终端时，这些导体的长度应为通过它们传播的扰动的波长的四分之一。

In the accompanying drawing I have shown graphically a disposition of apparatus which may be used in applying practically my invention.

在附图中，我已经展示了可以用于实际应用我的发明的设备的一个布置。

The drawing illustrates in perspective two devices, either of which may be the transmitter, while the other is the receiver. In each there is a coil of few turns and low resistance, (designated in one by A and in the other by A') . The former coil, supposed to be forming part of the transmitter, is to be connected with a suitable source of current, while the latter is to be included in circuit with a receiving device. In inductive relation to said coils in each instrument is a flat spirally-wound coil B or B', one terminal of which is shown as connected to a ground-plate C, while the other, leading from the center, is adapted to be connected to an insulated terminal, which is generally maintained at an elevation in the air. The coils B B' are placed in insulating-receptacles D, which contain the freezing agent and around which the coils A and A' are wound.

该图以透视图展示了两个设备，其中一个可以是发射器，而另一个是接收器。每个线圈都有一个匝数少、电阻低的线圈(一个用 A 表示，另一个用 A'表示)。前一个线圈被认为是发射器的一部分，将与合适的电流源连接，而后一个线圈将被包含在具有一个接收装置的电路中。与每个仪器中的所述线圈成感应关系的是扁平螺旋缠绕线圈 B 或 B'，其一个终端被图示为连接到接地板 C，而从中心引出的另一个终端适于连接到一个被绝缘终端，该终端通常保持在空气中的某一高度。线圈 B 和 B'被放置在绝缘容器 D 中，容器 D 中装有冷冻剂，线圈 A 和 A'缠绕在容器 D 上。

Coils in the form of a flat spiral, such as those described, are eminently suited for the production of free oscillations; but obviously conductors or circuits of any other form may be used, if desired.

扁平螺旋形式的线圈，例如所描述的那些，非常适合于产生自由振荡；但是如果需要，显然可以使用任何其他形式的导体或电路。

From the foregoing the operation of the apparatus will now be readily understood. Assume, first, as the simplest case that upon the coil A of the transmitter impulses or oscillations of an arbitrary frequency and irrespective of its own free vibrations are impressed. Corresponding oscillations will then be induced in the circuit B, which, being constructed and adjusted, as before indicated, so as to vibrate at the same rate, will greatly magnify them, the increase being directly proportionate to the product of the frequency of the oscillations and the inductance of circuit B and inversely to the resistance of the latter. Other conditions remaining the same, the intensity of the oscillations in the resonating-circuit B will be increased in the same proportion as its resistance is reduced. Very often, however, the conditions may be such that the gain sought is not realized directly by diminishing the resistance of the circuit. In such cases the skilled expert who applies the invention will turn to advantage the reduction of resistance by using a correspondingly longer conductor, thus securing a much greater self-induction, and under all circumstances he will determine the dimensions of the circuit, so as to get the greatest value of the ratio of its inductance to its resistance, which determines the intensity of the free oscillations. The vibrations of coil B, greatly strengthened, spread to a distance and on reaching the tuned receiving-conductor B' excite corresponding oscillations in the same, which for similar reasons are intensified, with the result of inducing correspondingly stronger currents or oscillations in circuit A', including the receiving device. When, as may be the case in the transmission of intelligible signals, the circuit A is periodically closed and opened, the effect upon the receiver is heightened in the manner above described not only because the impulses in the coils B and B' are strengthened, but also on account of their persistence through a

longer interval of time. The advantages offered by the invention are still more fully realized when the circuit A of the transmitter instead of having impulses of an arbitrary frequency impressed upon it is itself permitted to vibrate at its own rate, and more particularly so if it be energized by the freely-oscillating high-frequency discharges of a condenser. In such a case the cooling of the conductor A, which may be effected in any suitable manner, results in an extraordinary magnification of the oscillation in the resonating-circuit B, which I attribute to the increased intensity as well as greater number of the high-frequency oscillations obtained in the circuit A. The receiving-coil B' is energized stronger in proportion and induces currents of greater intensity in the circuit A'. It is evident from the above that the greater the number of the freely-vibrating circuits which alternately receive and transmit energy from one to another the greater, relatively, will be the gain secured by applying my invention.

根据前述内容，现在将容易理解该设备的操作。首先，作为最简单的情况，假设在发射器的线圈 A 上施加了任意频率的脉冲或振荡，而不考虑其自身的自由振动。相应的振荡将在电路 B 中被感应，如前所述，电路 B 被构造和调整，以便以相同的速率振动，将极大地放大它们，这种增加与振荡频率和电路 B 的电感的乘积成正比，与后者的电阻成反比。其他条件保持不变，谐振电路 B 中的振荡强度将随着其电阻的减小而以相同的比例增加。然而，通常情况下，所寻求的收益不能通过减小电路的电阻来直接实现。在这种情况下，应用本发明的熟练专家将通过使用一个相应的更长的导体来转而使减小电阻的做法处于有利的地位，从而确保更大的一个自感，并且在所有情况下，他将决定电路的尺寸，以便获得其电感与其电阻之比的最大值，这决定了自由振荡的强度。线圈 B 的大大增强的振动传播到一段距离，并在到达调谐的接收导体 B' 时在其中激发相应的振荡，由于类似的原因，该振荡被增强，结果在包含了接收装置的电路 A' 中感应出相应更强的电流或振荡。当电路 A 周期性地闭合和断开时，正如在可理解的信号的传输中的情况一样，对接收器的影响以上述方式增强，这不仅是因为线圈 B 和 B' 中的脉冲被加强，而且是因为它们经历更长的时间间隔能继续存在。当发送器的电路 A 不是具有施加在其上的任意频率的脉冲，而是它本身被允许以它自己的速率振荡时，由本发明提供的优点被更充分地实现，并且更特别地，如果它被电容器的自由振荡高频放电激励时更是如此。在这种情况下，可以以任何合适的方式对导体 A 进行冷却，这会导致谐振电路 B 中的振荡异常放大，这归因于在电路 A 中获得的更高的强度以及更大数量的高频振荡。接收线圈 B' 成比例地被更强地激励，并在电路 A' 中感应出更大强度的电流。从以上可以明显看出，交替地从一个到另一个接收和传输能量的自由振动电路的数量越多，应用我的发明所获得的收益相对就越大。

I do not of course intend to limit myself to the specific manner and means described of artificial cooling, nor to the particular forms and arrangements of the circuits shown. By taking advantage of the facts above pointed out and of the means described I have found it possible to secure a rise of electrical pressure in an excited circuit very many times greater than has heretofore been obtainable, and this result makes it practicable, among other things, to greatly extend the distance of transmission of signals and to exclude much more effectively interference with the same than has been possible heretofore.

当然，我并不打算将自己局限于所描述的人工冷却的特定方式和工具，也不局限于所示电路的特定形式和布置。通过利用上面指出的事实和所描述的工具，我发现有可能确保激励电路中的电压上升比迄今为止可获得的电压上升大很多倍，此外，这一结果使得大大扩展信号传输的距离和比以前更有效地排除干扰成为可能。

Having now described my invention, what I claim is—

现在描述了我的发明，我主张的是—

1. The combination with a circuit adapted to vibrate freely, of means for artificially cooling the same to a low temperature, as herein set forth.

1、如本文所述，适于自由振动的电路与用于将其人工冷却至低温的工具的组合。

2. In an apparatus for transmitting or receiving electrical impulses or oscillations, the combination with a primary and a secondary circuit, adapted to vibrate freely in response to the impressed oscillations, of means for artificially cooling the same to a low temperature, as herein set forth.

2、在用于发送或接收电脉冲或振荡的一个装置中的组合，它包括一个初级电路和次级电路，适于自由振动以响应于所施加的振荡，还包括用于人工地将其冷却到低温的工具，如上所述。

3. In a system for the transmission of electrical energy, a circuit upon which electrical oscillations are impressed, and which is adapted to vibrate freely, in combination with a receptacle containing an artificial refrigerant in which said circuit is immersed, as herein set forth.

3、在用于传输电能的一个系统中，有一种电路，电振荡施加在该电路上，并且该电路适于与容纳人造制冷剂的容器相结合而自由振动，所述电路浸没在该容器中，如本文所述。

4. The means of increasing the intensity of the electrical impulses or oscillations impressed upon a freely-vibrating circuit, consisting of an artificial refrigerant combined with and applied to such circuit and adapted to maintain the same at a low temperature.

4、增加施加在自由振动电路上的电脉冲或振荡强度的工具，由一种人工制冷剂组成，该制冷剂与该电路结合并应用于该电路，并适于在低温下保持该电路。

5. The means of intensifying and prolonging the electrical oscillations produced in a freely-vibrating circuit, consisting of an artificial refrigerant applied to such circuit and adapted to maintain the same at a uniformly low temperature.

5、增强和延长一个自由振动电路中产生的电振荡的工具，由应用于该电路的人工制冷剂组成，并适于将其保持一致地的低温下。

6. In a system for the transmission of energy, a series of transmitting and receiving circuits adapted to vibrate freely, in combination with means for artificially maintaining the same at a low temperature, as set forth.

5、在一个能量传输系统中，一连串适合于自由振动的发射电路和接收电路，与人工保持其低温的工具相结合，如前所述。

NIKOLA TESLA.

尼古拉·特斯拉

Witnesses:

JOHN C. KERR,

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见证人:

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No. 685,012.

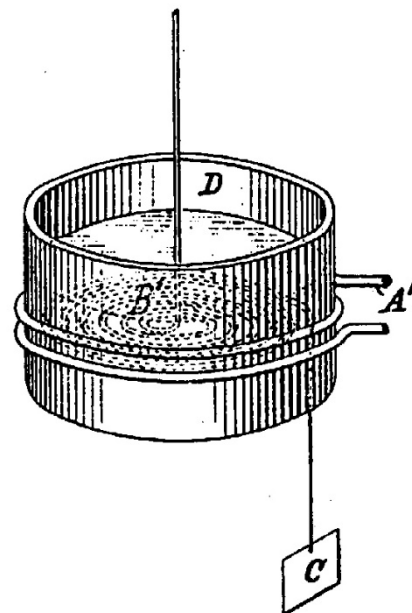
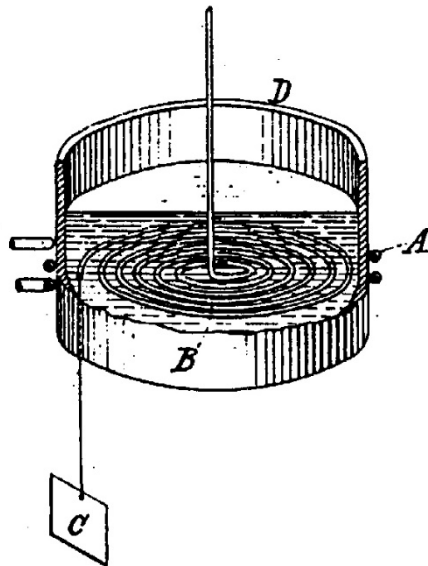
Patented Oct. 22, 1901.

N. TESLA.

MEANS FOR INCREASING THE INTENSITY OF ELECTRICAL OSCILLATIONS.

(Application filed Mar. 21, 1900. Renewed July 3, 1901.)

(No Model.)



Witnesses:

Raphael Ketter
Benjamin Miller.

Nikola Tesla, Inventor

by Kerr, Page & Cooper Attys.

METHOD OF INTENSIFYING EFFECTS TRANSMITTED THROUGH NATURAL MEDIA.

增强通过自然媒介传播的效果的方法

NIKOLA TESLA, OF NEW YORK, N. Y.

纽约州纽约市的尼古拉·特斯拉

SPECIFICATION forming part of Letters Patent No. 685,953, dated November 5, 1901.

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To all whom it may concern:

致所有相关人士:

Be it known that I, NIKOLA TESLA, a citizen of the United States, residing at New York, in the county and State of New York, have invented a new and useful Improvement in Methods of Intensifying and Utilizing Effects Transmitted Through the Natural Media, of which the following is a specification, reference being had to the accompanying drawings, which form a part of the same.

众所周知,我,尼古拉·特斯拉,美国公民,居住纽约州纽约郡纽约市,已经发明了一种新的和有用的改进方法,用来加强和利用通过自然媒体传播的效应,以下是该发明一个说明书,必须参考随附的图纸,它已形成该说明书的一部分。

The subject of my present invention is an improvement in the art of utilizing effects transmitted from a distance to a receiving device through the natural media; and it consists in a novel method by means of which results hitherto unattainable may be secured.

本发明的主题是对通过自然媒介从远处传输到接收设备的效应进行利用的技术的改进;并且它包括一种新颖的方法,通过该方法可以获得迄今为止无法实现的结果。

Several ways or methods of transmitting electrical disturbances through the natural media and utilizing them to operate distant receivers are now known and have been applied with more or less success for accomplishing a variety of useful results. One of these ways consists in producing by a suitable apparatus rays or radiations—that is, disturbances—which are propagated in straight lines through space, directing them upon a receiving or recording apparatus at a distance, and thereby bringing the latter into action. This method is the oldest and best known and has been brought particularly into prominence in recent years through the investigations of Heinrich Hertz. Another method consists in passing a current

through a circuit, preferably one enclosing a very large area, inducing thereby in a similar circuit situated at a distance another current and affecting by the same in any convenient way a receiving device. Still another way, which has also been known for many years, is to pass in any suitable manner a current through a portion of the ground, as by connecting to two points of the same, preferably at a considerable distance from each other, the two terminals of a generator and to energize by a part of the current diffused through the earth a distant circuit which is similarly arranged and grounded at two points widely apart and which is made to act upon a sensitive receiver. These various methods have their limitations, one especially, which is common to all, being that the receiving circuit or instrument must be maintained in a definite position with respect to the transmitting apparatus, which often imposes great disadvantages upon the use of the apparatus.

通过自然媒介传输电扰动并利用它们来操作远程接收器的几种方式或方法现在是已知的,并且已经或多或少成功地应用于实现各种有用的结果。其中一种方法是通过合适的装置产生射线或辐射——即扰动——这些射线或辐射在空间中直线传播,将它们导向远处的接收或记录装置,从而使后者起作用。这种方法是最古老的,也是最广为人知的,最近几年,通过海因里希·赫兹的研究,这种方法变得尤为突出。另一种方法是使电流通过一个电路,最好是包围很大面积的一个电路,从而在位于远处的一个类似电路中感应出另一个电流,并以任何方便的方式影响一个接收装置。还有另一种方法,也是多年来已知的,是以任何合适的方式使电流通过一部分地面,例如将一个发电机的两个终端通过连接地面的两个点,最好是相距很远的两个点,并通过地面来扩散一部分电流来激励远处的一个电路,该电路类似于布置并在相距很远的两个点接地,这两个点作用在一个灵敏的接收器上。这些不同的方法都有其局限性,尤其是一个普遍存在的局限性,即接收电路或接收仪器必须保持在相对于发射设备的确切位置,这通常给设备的使用带来很大的缺点。

In several applications filed by me and patents granted to me I have disclosed other methods of accomplishing results of this nature, which may be briefly described as follows: In one system the potential of a point or region of the earth is varied by imparting to it intermittent or alternating electrifications through one of the terminals of a suitable source of electrical disturbances which, to heighten the effect, has its other terminal connected to an insulated body, preferably of large surface and at an elevation. The electrifications communicated to the earth spread in all directions through the same, reaching a distant circuit which generally has its terminals arranged and connected similarly to those of the transmitting source and operates upon a highly-sensitive receiver. Another method is based upon the fact that the atmospheric air which behaves as an excellent insulator to currents generated by ordinary apparatus becomes a conductor under the influence of currents or impulses of enormously-high electromotive force which I have devised means for generating. By such means air strata, which are easily accessible, are rendered available for the production of many desired effects at distances, however great. This method, furthermore, allows advantage to be taken of many of those improvements which are practicable in the ordinary systems of transmission involving the use of a metallic conductor.

在我提交的几个申请和授予我的专利中,我已经公开了实现这种性质的结果的其他方法,可以简要描述如下:在一个系统中,大地的某一点或某一区域的电位是通过适当的电扰动源的一个终端向其施加间歇或交变的电流来改变的,为了提高效果,电扰动源的另一个终端连接到一个被绝缘体上,该被绝缘体最好具有较大的表面并位于一个高处。传到大地上的电流通过大地向四面八方传播,到达一个远距离的电路,该电路的终端一般与发射源的终端有着相似的布局 and 连接,并通过一个高灵敏度的接收器工作。另一种方法是基于这样一个事实,即对

于普通设备产生的电流表现为一种优秀的绝缘体的大气空气在非常高电动势的电流或脉冲影响下变成一种导体，我已经设计了产生这种极高电动势的工具。通过这种工具，容易接近的空气层可被用于在不同距离上产生许多所需的效果，无论距离有多远。此外，这种方法允许利用在涉及使用金属导体的普通传输系统中可行的许多改进。

Obviously whatever method be employed it is desirable that the disturbances produced by the transmitting apparatus should be as powerful as possible, and by the use of certain forms of high-frequency apparatus which I have devised and which are now well known important practical advantages are in this respect secured. Furthermore, since in most cases the amount of energy conveyed to the distant circuit is but a minute fraction of the total energy emanating from the source it is necessary for the attainment of the best results that whatever the character of the receiver and the nature of the disturbances as much as possible of the energy conveyed should be made available for the operation of the receiver, and with this object in view I have heretofore among other means employed a receiving-circuit of high self-induction and very small resistance and of a period such as to vibrate in synchronism with the disturbances, whereby a number of separate impulses from the source were made to cooperate, thus magnifying the effect exerted upon and insuring the action of the receiving device. By these means decided advantages have been secured in many instances; but very often the improvement is either not applicable at all or, if so, the gain is very slight. Evidently when the source is one producing a continuous pressure or delivering impulses of long duration it is impracticable to magnify the effects in this manner and when, on the other hand, it is one furnishing short impulses of extreme rapidity of succession the advantage obtained in this way is insignificant, owing to the radiation and the unavoidable frictional waste in the receiving-circuit. These losses reduce greatly both the intensity and the number of the cooperative impulses, and since the initial intensity of each of these is necessarily limited only an insignificant amount of energy is thus made available for a single operation of the receiver. As this amount is consequently dependent on the energy conveyed to the receiver by one single impulse it is evidently necessary to employ either a very large and costly, and therefore objectionable, transmitter or else to resort to the equally objectionable use of a receiving device too delicate and too easily deranged. Furthermore, the energy obtained through the cooperation of the impulses is in the form of extremely rapid vibrations and, because of this, unsuitable for the operation of ordinary receivers, the more so as this form of energy imposes narrow restrictions in regard to the mode and time of its application to such devices.

显然，无论采用什么方法，都希望由发射装置产生的扰动尽可能的强，并且通过使用我已经设计的并且现在众所周知的某些形式的高频装置，在这方面确保了重要的实际优点。此外，由于在大多数情况下，传送到远处电路的能量只占从源头发出的总能量的很小一部分，所以为了获得最佳结果，无论接收器的特性和扰动的性质如何，都应该使尽可能多的传送能量可用于接收器的操作，鉴于这个目的，我迄今为止在其他工具中采用了一个具有高自感和非常小的电阻的接收电路，且该电路的周期使其能与扰动同步振动，由此来自源头的许多单独的脉冲被迫协作，从而放大影响和确保接收设备的作用。通过这些工具，在许多情况下都获得了明显的优势；但很多时候，这种改进要么根本不适用，要么就算适用，收益也非常小。显然，当源头是一个产生连续压力或传递长时间脉冲的源头时，用这种方式放大效果是不切实际的，而另一方面，当源头是一个提供极端快速连续的短脉冲的源头时，由于辐射和接收电路中不可避免的摩擦损耗，以这种方式获得的优势也是微不足道的。这些损耗大大降低了协同脉冲的强度和数量，并且由于这些协同脉冲的每一个的初始强度必然是有限的，因此只有少量的能量可用于接收器的单次操作。由于这个量因此依赖于由一个单个脉冲传送到接收器

的能量，显然有必要使用非常大，并且昂贵，因此令人讨厌的发射器，或者求助于同样令人讨厌的使用过于精密且太容易混乱的接收装置。此外，通过脉冲协作获得的能量是以极快振动的形式存在的，因此不适合普通接收器的操作，尤其是这种形式的能量对于应用此能量的设备的模式和时间有着严格的限制。

To overcome these and other limitations and disadvantages which have heretofore existed in such systems of transmission of signals or intelligence is the main object of my present invention, which comprises a novel method of accomplishing these ends.

本发明的主要目的是克服迄今为止在这种信号或情报传输系统中存在的这些和其他的限制和缺点，本发明包括实现这些目的的新方法。

The method, briefly stated, consists in producing arbitrarily-varied or intermittent disturbances or effects, transmitting such disturbances or effects through the natural media to a distant receiving-station, utilizing energy derived from such disturbances or effects at the receiving-station to charge a condenser, and using the accumulated potential energy so obtained to operate a receiving device.

简而言之，该方法包括产生任意变化的或间歇的扰动或效应，通过自然媒介将这种扰动或效应传输到远处的接收站，在接收站利用从这种扰动或效应中获得的能量给电容器充电，并使用如此获得的累积势能来操作接收设备。

An apparatus by means of which this method may be practiced is illustrated in the drawings hereto annexed, in which—

在附图中展示了一种装置，通过该装置可以实施该方法，其中—

Figure 1 is a diagrammatic illustration of the apparatus, and Fig. 2 is a modified form or arrangement of the same.

图1是该装置的示意图，图2是该装置的改进的一个形式或布置。

In the practical application of my method I usually proceed as follows: At any two points in the transmitting medium between which there exists or may be obtained in any manner through the action of the disturbances or effects to be investigated or utilized a difference of electrical potential of any magnitude I arrange two plates or electrodes so that they may be oppositely charged through the agency of such effects or disturbances, and I connect these electrodes to the terminals of a highly-insulated condenser, generally of considerable capacity. To the condenser-terminals I also connect the receiver to be operated in series with a device of suitable construction, which performs the function of periodically discharging the condenser through the receiver at and during such intervals of time as may be best suitable for the purpose contemplated. This device may merely consist of two stationary electrodes separated by a feeble dielectric layer of minute thickness or it may comprise terminals one or more of which are movable and actuated by any suitable force and are adapted to be brought into and out of contact with each other in any convenient manner. It will now be readily seen that if the disturbances of whatever nature they may be cause definite amounts of electricity of the same sign to be conveyed to each of the plates or electrodes above mentioned, either continuously or at intervals of

time which are sufficiently long, the condenser will be charged to a certain potential, and an adequate amount of energy being thus stored during the time determined by the device effecting the discharge of the condenser the receiver will be periodically operated by the electrical energy so accumulated; but very often the character of the impulses and the conditions of their use are such that without further provision not enough potential energy would be accumulated in the condenser to operate the receiving-devices. This is the case when, for example, each of the plates or terminals receives electricity of rapidly-changing sign or even when each receives electricity of the same sign, but only during periods which are short as compared with the intervals separating them. In such instances I resort to the use of a special device which I insert in the circuit between the plates and the condenser for the purpose of conveying to each of the terminals of the latter electrical charges of the proper quality and order of succession to enable the required amount of potential energy to be stored in the condenser.

在我的方法的实际应用中，我通常如下进行：在传输媒介中的任意两点之间，存在或可以以任何方式通过要研究或利用的扰动或效应的作用获得任意大小的电势差。我布置两个板或电极，以便它们可以通过这种效应或扰动的作用带相反的电荷，我将这些电极连接到被一个高度绝缘的电容器的两个终端上，该电容器通常具有相当大的电容量。我还将接收器连接到电容器的两个终端上，该接收器与一个适当构造的装置串联操作，该装置的功能是通过接收器以最适合预期目的的时间间隔（或在最适合预期目的的时间间隔期间）周期性地使电容器放电。该装置可以仅由被微小厚度的弱介电层隔开的两个静态电极组成，或者它可以包括终端，其中一个或多个是可移动的，并且由任何适合的力驱动，并且适于以任何方便的方式彼此接触和脱离接触。现在可以很容易地看出，如果不管是什么性质的扰动，它们可以导致在连续的或以足够长的时间间隔由相同符号的确定量的电输送到上述的每个板或电极，电容器将被充电到某一电势，并且在由实现电容器放电的装置所确定的时间期间，存储了足够量的能量，接收器将由这样积累的电能周期性地操作；但是通常脉冲的特性和它们的使用条件是这样的，如果没有进一步的准备，在电容器中不会积累足够的势能来操作接收装置。例如，当每个板或终端接收到快速变化符号的电力时，或者甚至当每个板或终端接收到相同符号的电时，都是这种情况，但仅在与分隔它们的时间间隔相比较短的时间段内。在这种情况下，我求助于使用一种特殊的装置，我插入的在板和电容器之间的电路，目的是将适当品质和序列顺序的电荷传输到后者的每个终端，以使所需量的势能存储在电容器中。

There are a number of well-known devices, either without any moving parts or terminals or with elements reciprocated or rotated by the application of a suitable force, which offer a more ready passage to impulses of one sign or direction than to those of the other, or permit only impulses of one kind or order of succession to traverse a path, and any of these or similar devices capable of fulfilling the requirements may be used in carrying my invention into practice. One such device of familiar construction which will serve to convey a clear understanding of this part of my invention and enable a person skilled in the art to apply the same is illustrated in the annexed drawings. It consists of a cylinder A of insulating material, which is moved at a uniform rate of speed by clockwork or other suitable motive power and is provided with two metal rings B B', upon which bear brushes a and a', which are connected, respectively, in the manner shown to the terminal plates P and P', above referred to. From the rings B B' extend narrow metallic segments s and s', which by the rotation of the cylinder A are brought alternately into contact with double brushes b and b', carried by and in contact with conducting-holders h and h', which are adjustable longitudinally in the metallic supports D and D', as shown. The latter are connected to the terminals T and T' of a condenser C, and it should be understood that they are capable of angular displacement, as ordinary brush-supports. The object of using two

brushes, as b and b', in each of the holders h and h' is to vary at will the duration of the electric contact of the plates P and P' with the terminals T and T', to which is connected a receiving-circuit including a receiver R and a device d of the kind above referred to, which performs the duty of closing the receiving-circuit at predetermined intervals of time and discharging the stored energy through the receiver. In the present case this device consists of a cylinder d, made partly of conducting and partly of insulating material e and e', respectively, which is rotated at the desired rate of speed by any suitable means. The conducting part e is in good electrical connection with the shaft S and is provided with tapering segments f f, upon which slides a brush k, supported on a conducting-rod l, capable of longitudinal adjustment in a metallic support m. Another brush n is arranged to bear upon the shaft S, and it will be seen that whenever one of the segments f comes in contact with the brush k the circuit, including the receiver R, is completed and the condenser discharged through the same. By an adjustment of the speed of rotation of the cylinder d and a displacement of the brush k along the cylinder the circuit may be made to open and close in as rapid succession and remain open or closed during such intervals of time as may be desired. The plates P and P', through which the electrifications are conveyed to the brushes a and a', may be at a considerable distance from each other and both in the ground or both in the air, or one in the ground and the other in the air, preferably at some height, or they may be connected to conductors extending to some distance or to the terminals of any kind of apparatus supplying electrical energy which is obtained from the energy of the impulses or disturbances transmitted from a distance through the natural media.

有许多众所周知的装置，或者没有任何移动部件或终端，或者具有通过施加适当的力能往复运动或旋转的组件，这些装置为一种符号或一种方向的脉冲提供比另一种符号或方向的脉冲更容易的通道，或者仅允许一种类型或一种序列顺序的脉冲通过路径，并且能够满足要求的这些装置或类似装置中的任何一个都可以用于实施我的发明。在附图中展示了一种类似结构的装置，该装置将用于传达对本发明的这一部分的清楚理解，并使本领域技术人员能够应用该装置。它由绝缘材料制成的圆筒 A 组成，该圆筒由发条装置或其它合适的动力以一致的速度移动，并设有两个金属环 B B'，在金属环 B B'上装有电刷 a 和 a'，电刷 a 和 a'分别以上述所示的方式连接到终端板 P 和 P'上。从环 B B'延伸出窄的金属段 s 和 s'，通过圆筒 A 的旋转，金属段交替地与双电刷 b 和 b'接触，双电刷 b 和 b'由导电支架 h 和 h'承载并与之接触，导电支架 h 和 h'在金属支架 D 和 D'中可纵向调节，如图所示。后者连接到电容器 C 的终端 T 和 T'，应该理解，终端 T 和 T'能够像普通电刷支架一样进行角位移。在每个支架 h 和 h'中使用如 b 和 b'这样的两个电刷的目的是随意改变板 P 和 P'与终端 T 和 T'的电接触持续时间，终端 T 和 T'连接有接收电路，该接收电路包括一个接收器 R 和上述类型的一个装置 d，该装置 d 以预定的时间间隔闭合接收电路并通过接收器释放存储的能量。在这种情况下，该装置包括一个圆筒 d，一部分由导电材料 e 制成和一部分由绝缘材料 e'制成，该圆筒通过任何合适的工具以所需的速度旋转。导电部分 e 与轴 S 具有良好的电连接，并配有锥形分段 f f，在锥形分段 f f 上滑动一个电刷 k，电刷 k 由一个导电杆 l 支撑，导电杆 l 能够在金属支架 m 中纵向调节另一个电刷 n，后者被布置成倚靠在轴 S 上，可以看出，每当一个分段 f 与电刷 k 接触时，包括接收器 R 在内的电路接通，电容器通过该电路放电。通过调节圆筒 d 的转速和刷子 k 沿滚筒的位移，可以使该电路快速连续地断开和闭合，并在所需的时间间隔期间保持断开和闭合。通过板 P 和 P'将电气化传送到电刷 a 和 a'，板 P 和 P'可以彼此相距相当远，并且都在地面下或都在空中，或者一个在地面下而另一个在空中，最好是在某个高度上，或者它们可以连接到延伸到某个距离的导体上，或者它们可以连接到已经延伸到某个距离的导体上，或者连接到任何一种提供电能的装置的不同终端上，该电能是从远处通过自然媒介传输的脉冲或扰动的能量中获得的。

In illustration of the operation of the devices described let it be assumed that alternating electrical impulses from a distant generator, as G, are transmitted through the earth and that it is desired to utilize those impulses in accordance with my method. This may be the case, for example, when such a generator is used for purposes of signaling in one of the ways before enumerated, as by having its terminals connected to two points of the earth distant from each other. In this case the plates P and P' are first connected to two properly-selected points of the earth. The speed of rotation of the cylinder A is varied until it is made to turn in synchronism with the alternate impulses of the generator, and, finally, the position of the brushes b and b' is adjusted by angular displacement, as usual, or in other ways, so that they are in contact with the segments s and s' during the periods when the impulses are at or near the maximum of their intensity. Only ordinary electrical skill and knowledge are required to make these adjustments, and a number of devices for effecting synchronous movement being well known, and it being the chief object of my present application to set forth a novel method or utilizing or applying a principle, a detailed description of such devices is not considered necessary. I may state, however, that for practical purposes in the present case it is only necessary to shift the brushes forward or back until the maximum effect is secured. The above requirements being fulfilled, electrical charges of the same sign will be conveyed to each of the condenser-terminals as the cylinder A is rotated, and with each fresh impulse the condenser will be charged to a higher potential. The speed of rotation of the cylinder d being adjustable at will, the energy of any number of separate impulses may thus be accumulated in potential form and discharged through the receiver R upon the brush k coming in contact with one of the segments f. It will be of course understood that the capacity of the condenser should be such as to allow the storing of a much greater amount of energy than is required for the ordinary operation of the receiver. Since by this method a relatively great amount of energy and in a suitable form may be made available for the operation of a receiver, the latter need not be very sensitive; but of course when the impulses are very feeble, as when coming from a great distance or when it is desired to operate a receiver very rapidly, then any of the well-known devices capable of responding to very feeble influences may be used in this connection.

在说明所述设备的操作时，假设来自远处发电机（如 G）的交流电脉冲，通过大地传输，并且希望根据我的方法利用那些脉冲。例如，当这种发电机用于以前面列举的方式之一发送信号时，例如通过将其终端连接到地球上彼此远离的两点，就可能是这种情况。在这种情况下，板 P 和 P' 首先连接到地球的两个适当选择的点。圆筒 A 的转速是变化的，直到它与发电机的交变脉冲同步，最后，刷 b 和 b' 的位置由角位移来调节，如通常那样，或以其它方式，这样，在脉冲强度达到或接近最大值时，电刷 b 和 b' 与分段 s 和 s' 接触。进行这些调整只需要普通的电气技能和知识，并且许多用于实现同步运动的装置是众所周知的，并且我的本申请的主要目的是提出一种新颖的方法或利用或应用一种原理，对这些装置的详细描述被认为是不必要的。然而，我可以声明，实际上在这种情况下，只需要向前或向后移动电刷，直到获得最大效果。满足上述要求，当圆柱体 A 旋转时，相同符号的电荷将被传送到每个电容器的终端上，并且随着每个新的脉冲，电容器将被充电到更高的电势。圆柱体 d 的旋转速度可以随意调节，因此任何数量的独立脉冲的能量可以以电势的形式积累，并在电刷 k 与其中一个分段 f 接触时通过接收器 R 放电。当然可以理解，电容器的容量应该允许储存比接收器正常工作所需的能量大得多的能量。因为通过这种方法，相对大量的能量以一个适当的形式可以用于一个接收器的操作，所以后者不需要非常敏感；但是当然，当脉冲非常微弱时，例如当来自很远的距离时，或者当希望非常快速地操作接收器时，则可以在这种连接中使用能够响应非常微弱的影响的任何众所周知的设备。

If instead of the alternating impulses short impulses of the same direction are conveyed to the plates P and P', the apparatus described may still readily be used, and for this purpose it is merely necessary to shift the brushes b and b' into the position indicated by the dotted lines while maintaining the same conditions in regard to synchronism as before, so that the succeeding impulses will be permitted to pass into the condenser, but prevented from returning to the ground or transmitting medium during the intervals between them, owing to the interruption during such intervals of the connections leading from the condenser-terminals to the plates.

如果不是交流脉冲，而是相同方向的短脉冲被传送到板 P 和 P'，所述装置仍然可以容易地使用，为此目的，只需要将电刷 b 和 b' 移动到虚线所示的位置，同时保持与前面相同的同步状态，以便允许随后的脉冲进入电容器，但是在它们之间的时间间隔期间，由于从电容器终端到板的连接在这种时间间隔期间的中断，防止返回到接地或传输媒介。

Another way of using the apparatus with impulses of the same direction is to take off one pair of brushes, as b, disconnect the plate P from brush a and join it directly to the terminal T of the condenser, and to connect brush a with brush a'. The apparatus thus modified would appear as shown in Fig. 2. Operated in this manner and assuming the speed of rotation of cylinder A to be the same, the apparatus will now be evidently adapted for a number of impulses per unit of time twice as great as in the preceding case. In all cases it is evidently important to adjust the duration of contact of segments s and s' with brushes b b' in the manner indicated.

使用具有相同方向脉冲的装置的另一种方法是取下一对电刷，如 b，将板 P 从电刷 a 上断开，并将其直接连接到电容器的终端 T 上，并将电刷 a 与电刷 a' 连接起来。如此修改的设备将如图 2 所示。以这种方式操作并假设圆筒 A 的转速相同，该装置现在将明显地适用于每单位时间的脉冲数量是前一种情况的单位时间内的两倍的情况。在所有情况下，以指定的方式调节分段 s 和 s' 与电刷 b 和 b' 的接触时间显然是很重要的。

When the method and apparatus I have described are used in connection with the transmission of signals or intelligence, it will of course be understood that the transmitter is operated in such a way as to produce disturbances or effects which are varied or intermitted in some arbitrary manner—for example, to produce longer and shorter successions of impulses corresponding to the dashes and dots of the Morse alphabet—and the receiving device will respond to and indicate these variations or intermittences, since the storage device will be charged and discharged a number of times corresponding to the duration of the successions of impulses received.

当我所描述的方法和装置与信号或情报的传输结合使用时，当然可以理解，发射机以这样一种方式工作，来产生以某种任意方式变化或间断的扰动或影响，例如，产生对应于莫尔斯字母表的破折号和点的较长或较短的脉冲序列，并且接收设备将响应并指示这些变化或间断，因为储能设备将被充电和放电多次对应于所接收的脉冲序列的持续时间。

Obviously the special appliances used in carrying out my invention may be varied in many ways without departing from the spirit of the same.

显然，在不脱离本发明的精神的情况下，用于实现我的发明的特殊装置可以以多种方式变化。

It is to be observed that it is the function of the cylinder A, with its brushes and connections to render the electrical impulses coming from the plates P and P' suitable for charging the condenser (assuming them to be unsuitable for this purpose in the form in which they are received) by rectifying them when they are originally alternating in direction or by selecting such parts of them as are suitable when all are not, and any other device performing this function will obviously answer the purpose. It is also evident that a device such as I have already referred to which offers a more ready passage to impulses of one sign or permits only impulses of the same sign to pass may also be used to perform this selective function in many cases when alternating impulses are received. When the impulses are long and all of the same direction, and even when they are alternating, but sufficiently long in duration and sustained in electromotive force, the brushes b and b' may be adjusted so as to bear on the parts B B' of the cylinder A, or the cylinder and its brushes may be omitted and the terminals of the condenser connected directly to the plates P and P'.

可以观察到，具有电刷和连接的圆筒 A 的功能是使来自板 P 和 P' 的电脉冲适合于给电容器充电（假设它们是以不适合此目的方式被接收），当它们的最初方向交替时通过换向它们，或者当它们在所有方向上都不交替时通过选择它们中适合的部分，并且执行该功能的任何其他装置将显然满足该目的。同样明显的是，在许多情况下，当接收到交替的脉冲时，诸如我已经提到的为一个符号的脉冲提供更容易的通道或者只允许相同符号的脉冲通过的装置也可以用于执行这种选择功能。当脉冲很长并且都是同一个方向时，甚至当它们是交变的，但是持续时间足够长并且维持电动势时，电刷 B 和 B' 可以被调整以便倚靠在圆筒 A 的分段 B B' 上，或者圆筒及其电刷可以被省略，电容器的终端直接连接到板 P 和 P' 上。

It will be seen that by the use of my invention results hitherto unattainable in utilizing disturbances or effects transmitted through natural media may be readily attained, since however great the distance of such transmission and however feeble or attenuated the impulses received enough energy may be accumulated from them by storing up the energy of succeeding impulses for a sufficient interval of time to render the sudden liberation of it highly effective in operating a receiver. In this way receivers of a variety of forms may be made to respond effectively to impulses too feeble to be detected or to be made to produce any sensible effect in any other way of which I am aware, a result of great value in various applications to practical use.

可以看出，通过使用我的发明，可以容易地获得迄今为止在利用通过自然媒介传输的扰动或效应方面无法获得的结果，因为无论这种传输的距离有多远，无论接收到的脉冲有多么微弱或多么减弱，足够的能量可以通过存储随后的脉冲的能量由这些脉冲积累足够长的一段时间间隔，以使能量的突然释放在操作接收器时非常有效。通过这种方式，可以使各种形式的接收器有效地响应太微弱而无法检测到的脉冲，或者以我所知道的任何其他方式产生任何可感知的效果，这一结果在实际应用中具有很大的价值。

I do not claim herein an apparatus by means of which the above-described method is or may be practiced either in the special form herein shown or in other forms which are possible, having made claims to such apparatus in another application, Serial No. 729,812, filed September 8, 1899, as a division of the present case.

我在此不对一种装置提出主张，通过该装置可以或也许以这里所示的特殊形式或以其他可能的形式实施上述方法，我已在另一申请中对这种装置提出主张要求，序列号为 729,812，于

1899 年 9 月 8 日提交，作为本案的一个分立。

What I claim as my invention, and desire to secure by Letters Patent, is—

我主张的是我的发明，并希望通过专利证书来保护的是—

1. The method of transmitting and utilizing electrical energy herein described, which consists in producing arbitrarily varied or intermitted electrical disturbances or effects, transmitting the same to a distant receiving-station, charging for succeeding and predetermined periods of time a condenser with energy derived from such effects or disturbances, and operating a receiving device by discharging at arbitrary intervals, the accumulated potential energy so obtained, as set forth.

1、在此描述的传输和利用电能的方法，包括产生任意变化或间断的电扰动或效应，将其传输到远处的接收站，在随后的预定时间周期内利用从这种效应或扰动中获得的能量对一个电容器充电，并通过以任意时间间隔释放如此获得的累积势能来操作接收装置，如上所述。

2. The method of transmitting and utilizing electrical energy herein described, which consists in producing electrical disturbances or effects capable of being transmitted to a distance through the natural media, charging a condenser at a distant receiving-station with energy derived from such effects or disturbances, and using for periods of time, predetermined as to succession and duration, the potential energy so obtained to operate a receiving device.

2、这里描述的传输和利用电能的方法，包括产生能够通过自然媒介传输到远处的电扰动或效应，利用从这种效应或扰动获得的能量给一个远处接收站的一个电容器充电，使用如此获得的势能在预定的连续和持续时间内操作接收设备。

3. The method of transmitting and utilizing electrical energy herein described, which consists in producing electrical disturbances or effects capable of being transmitted to a distance through the natural media, charging a condenser at a distant receiving-station for succeeding and predetermined periods of time, with energy derived from such effects or disturbances, and using for periods of time predetermined as to succession and duration, the accumulated energy so obtained to operate a receiving device.

3、这里描述的传输和利用电能的方法，包括产生能够通过自然媒介传输到远处的电扰动或效应，在随后的预定时间周期内，利用从这种效应或扰动获得的能量对一个远处接收站的一个电容器充电，使用如此获得的累积能量在预定的连续和持续时间内操作接收设备。

4. The method hereinbefore described of producing arbitrarily varied or intermitted electrical disturbances or effects, transmitting such disturbances or effects through the natural media to a distant receiving-station, storing in a condenser energy derived from a succession of such disturbances or effects for periods of time which correspond in succession to such effects or disturbances and are predetermined as to duration, and using the accumulated potential energy so obtained to operate a receiving device.

4、上文所述的产生任意变化或间歇的电扰动或效应的方法，它是通过自然媒介将这种扰动

或效应传输到远处的接收站，在一个电容器中存储了从一系列这种扰动或效应中获得的能量，存储的时间周期连续地对应于这种效应或扰动，并且是预先确定的，并使用如此获得的累积势能来操作接收设备。

5. The method herein described of producing arbitrarily varied or intermitted electrical disturbances or effects, transmitting such disturbances or effects through the natural media to a distant receiving-station, establishing thereby a flow of electrical energy in a circuit at such station, charging a condenser with energy from such circuit, and using the accumulated potential energy so obtained to operate a receiving device.

5、这里描述的产生任意变化或间断的电扰动或效应的方法，它是通过自然媒介将这种扰动或效应传输到一个远处的接收站，从而在该站的电路中建立一个电能流，用来自该电路的能量给电容器充电，并使用如此获得的累积势能来操作接收设备。

6. The method herein described of producing arbitrarily varied or intermitted electrical disturbances or effects, transmitting such disturbances or effects through the natural media to a distant receiving-station, establishing thereby a flow of electrical energy in a circuit at such station, charging a condenser with electrical energy from such circuit, and discharging the accumulated potential energy so obtained into or through a receiving device at arbitrary intervals of time.

6、这里描述的产生任意变化或间歇的电扰动或效应的方法，它是通过自然媒介将这种扰动或效应传输到一个远处的接收站，从而在该站的电路中建立电能流，用来自该电路的电能给电容器充电，并以任意时间间隔将如此获得的累积势能释放到一个接收装置中或通过一个接收装置释放。

7. The method herein described of producing arbitrarily varied or intermitted electrical disturbances or effects, transmitting such disturbances or effects to a distant receiving-station, establishing thereby a flow of electrical energy in a circuit at such station, selecting or directing the impulses in said circuit so as to render them suitable for charging a condenser, charging a condenser with the impulses so selected or directed, and discharging the accumulated potential energy so obtained into, or through a receiving device.

7、这里描述的产生任意变化或间断的电扰动或效应的方法，将这种扰动或效应传输到一个远处的接收站，从而在该站的电路中建立电能流，选择或引导所述电路中的脉冲以使它们适合于对电容器充电，利用如此选择或引导的脉冲对电容器充电，并将如此获得的累积势能释放到一个接收装置中或通过一个接收装置释放。

8. The method herein described of producing arbitrarily varied or intermitted electrical disturbances or effects, transmitting such disturbances or effects through the natural media to a distant receiving-station, establishing thereby a flow of electrical energy in a circuit at such station, selecting or directing the impulses in said circuit so as to render them suitable for charging a condenser, charging a condenser with the impulses so selected or directed, and discharging the accumulated potential energy so obtained into, or through a receiving device at arbitrary intervals of time.

8、这里描述的产生任意变化或间歇的电扰动或效应的方法，它是通过自然媒介将这种扰动

或效应传输到远处的接收站，从而在这种站的电路中建立电能流，选择或引导所述电路中的脉冲以使它们适合于对电容器充电，用如此选择或引导的脉冲对电容器充电，并以任意时间间隔将如此获得的累积势能释放到接收装置中或通过接收装置释放。

9. The method hereinbefore described of transmitting signals or intelligence, which consists in producing at the a sending-station arbitrarily varied or intermitted disturbances or effects, transmitting such disturbances or effects through the natural media to a receiving-station, utilizing energy derived from such disturbances or effects at the receiving-station to charge a condenser and using the accumulated potential energy so obtained to operate a receiving device.

9、上文所述的发送信号或情报的方法，包括在一个发送站产生任意变化或间断的扰动或影响，通过自然媒介将这种扰动或影响发送到一个接收站，在该接收站利用从这种扰动或影响中获得的能量给电容器充电，并利用如此获得的累积势能来操作一个接收设备。

10. The method hereinbefore described of transmitting signals or intelligence through the natural media from a sending-station to a receiving-station, which consists in producing at the sending-station, arbitrarily varied or intermitted electrical effects or disturbances, transmitting the same through the natural media to the receiving-station, utilizing the energy derived from such disturbances or effects at the receiving-station to charge a condenser, and discharging the accumulated potential energy so obtained through a receiving device at arbitrary intervals of time.

10、上文所述的通过自然媒介将信号或情报从一个发送站传输到一个接收站的方法，包括在发送站产生任意变化或间断的电效应或扰动，通过自然媒介将电效应或扰动传输到接收站，在接收站利用从这种扰动或效应中获得的能量给电容器充电，并以任意时间间隔通过接收装置释放如此获得的累积势能。

11. The method hereinbefore described of transmitting signals or intelligence from a sending to a distant receiving station, which consists in producing at the former, arbitrarily varied or intermitted electrical disturbances or effects, transmitting the same to the receiving-station, charging by the energy derived from such disturbances or effects at the receiving-station a condenser, and using for periods of time predetermined as to succession and duration, the potential energy so obtained to operate a receiving device, as set forth.

11、上文所述的将信号或情报从一个发送站发送到远处的一个接收站的方法，包括在发送站产生任意变化或间断的电扰动或效应，将其发送到接收站，在接收站用来自这种扰动或效应的能量对电容器充电，并在预定的连续和持续时间内使用如此获得的势能来操作接收设备，如上所述。

NIKOLA TESLA.

尼古拉·特斯拉

Witnesses:

LEONARD E. CURTIS,

A. E. SKINNER.

见证人:

伦纳德·E·柯蒂斯、A.E.斯金纳。

N. TESLA.

METHOD OF INTENSIFYING AND UTILIZING EFFECTS TRANSMITTED THROUGH
NATURAL MEDIA.

(Application filed June 24, 1899. Renewed May 29, 1901.)

(No Model.)

Fig. 1.

(G)

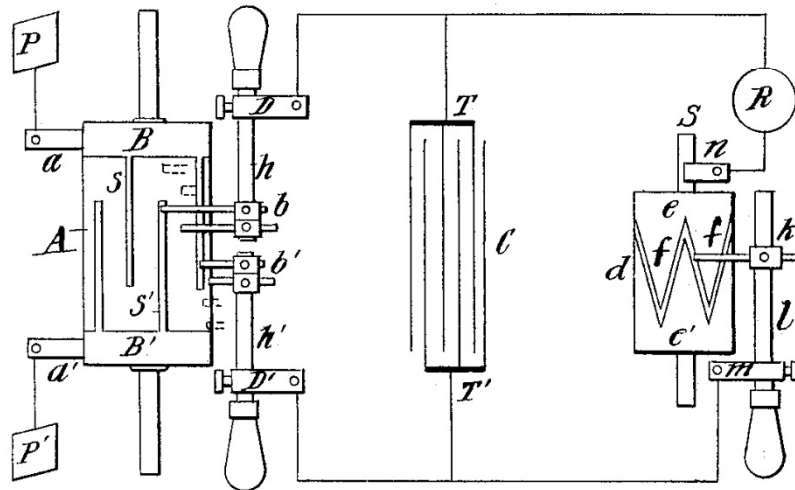
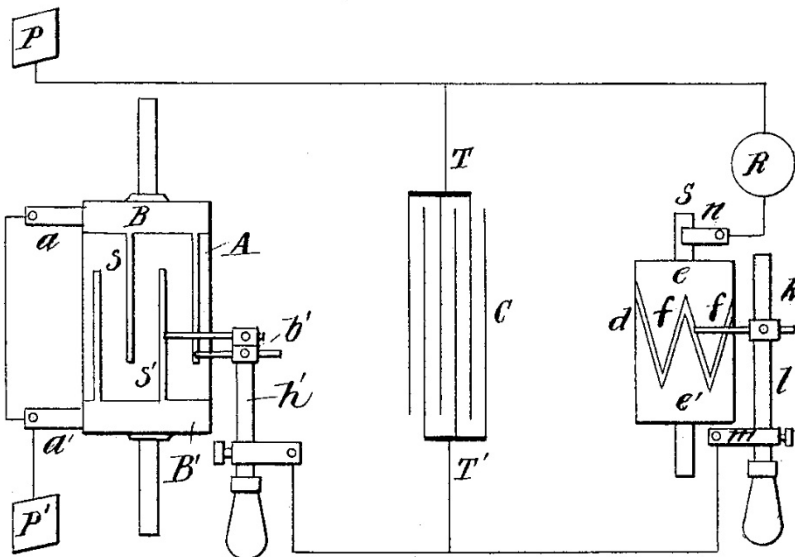


Fig. 2.

(G)



Witnesses:

J. B. Lewis.
Hellary C. Messimer

Nikola Tesla, Inventor

by Kerr, Page & Cooper
Att'ys

METHOD OF UTILIZING EFFECTS TRANSMITTED THROUGH NATURAL MEDIA.

利用通过自然媒介传播的效果的方法

NIKOLA TESLA, OF NEW YORK, N. Y.

纽约州纽约市的尼古拉·特斯拉

SPECIFICATION forming part of Letters Patent No. 685,954, dated November 5, 1901.

Application filed August 1, 1899. Renewed May 29, 1901. Serial No. 62,316. (No model.)

该说明书形成了颁发于 1901 年 11 月 5 日编号为 685,954 的专利证书的一部分。

申请于 1899 年 8 月 1 日提交。1901 年 5 月 29 日更新。序列号 62,316。(没有模型)

To all whom it may concern:

致所有相关人士:

Be it known that I, NIKOLA TESLA, a citizen of the United States, residing at New York city, in the county and State of New York, have invented a new and useful Improvement in Methods Utilizing Effects Transmitted from a Distance to a Receiving Device Through the Natural Media, of which the following is a specification, reference being had to the accompanying drawings, which form a part of the same.

众所周知，我，尼古拉·特斯拉，美国公民，居住在纽约州纽约郡纽约市，在利用从一个远处通过自然媒介传输到一个接收设备的效果方面已经发明了一种新的和有用的改进方法，以下是该发明一个说明书，必须参考随附的图纸，它已形成该说明书的一部分。

The subject of my present invention is an improvement in the art of utilizing effects transmitted from a distance to a receiving device through the natural media; and it consists in a novel method hereinafter described.

本发明的主题是对利用从一个远处通过自然媒介传输到一个接收设备的效果的技术的改进；并且它存在于下文描述的新方法中。

My invention is particularly useful in connection with methods and apparatus for operating distant receiving devices by means of electrical disturbances produced by proper transmitters and conveyed to such receiving devices through the natural media; but it obviously has a wider range of applicability and may be employed, for example, in the investigation or utilization of terrestrial, solar, or other disturbances produced by natural causes.

我的发明特别适用于由适当的发射器产生并通过自然媒介传送到这些接收设备的电扰动来

操作远距离接收设备的方法和装置；但它显然具有更广泛的适用性，例如可用于研究或利用由地球、太阳或其他由自然原因产生的扰动。

Several ways or methods of transmitting electrical disturbances through the natural media and utilizing them to operate distant receivers are now known and have been applied with more or less success for accomplishing a variety of useful results. One of these ways consists in producing by a suitable apparatus rays or radiations—that is, disturbances—which are propagated in straight lines through space, directing them upon a receiving or recording apparatus at a distance, and thereby bringing the latter into action. This method is the oldest and best known and has been brought particularly into prominence in recent years through the investigations of Heinrich Hertz. Another method consists in passing a current through a circuit, preferably one enclosing a very large area, inducing thereby in a similar circuit situated at a distance another current and affecting by the same in any convenient way a receiving device. Still another way, which has also been known for many years, is to pass in any suitable manner a current through a portion of the ground, as by connecting to two points of the same, preferably at a considerable distance from each other, the two terminals of a generator and to energize by a part of the current diffused through the earth a distant circuit, which is similarly arranged and grounded at two points widely apart and which is made to act upon a sensitive receiver. These various methods have their limitations, one especially, which is common to all, being that the receiving circuit or instrument must be maintained in a definite position with respect to the transmitting apparatus, which often imposes great disadvantages upon the use of the apparatus.

通过自然媒介传输电扰动并利用它们来操作远程接收器的几种方式或方法现在是已知的，并且已经或多或少成功地应用于实现各种有用的结果。其中一种方法是通过一个合适的装置产生射线或辐射——即扰动——这些射线或辐射在空间中沿着直线传播，将它们导向远处的接收或记录装置，从而使后者起作用。这种方法是最古老的，也是最广为人知的，最近几年，通过海因里希·赫兹的研究，这种方法变得尤为突出。另一种方法是使电流通过一个电路，最好是包围很大面积的一个电路，从而在位于远处的一个类似电路中感应出另一个电流，并以任何方便的方式影响一个接收装置。还有另一种方法，也是多年来已知的，是以任何合适的方式使电流通过一部分地面，例如将一个发电机的两个终端通过连接地面的两个点，最好是相距很远的两个点，并通过地面来扩散一部分电流来激励远处的一个电路，该电路类似于布置并在相距很远的两个点接地，这两个点作用在一个灵敏的接收器上。这些不同的方法都有其局限性，尤其是一个普遍存在的局限性，即接收电路或接收仪器必须保持在相对于发射设备的确定位置，这通常给设备的使用带来很大的缺点。

In several applications filed by me and patents granted to me I have disclosed other methods of accomplishing results of this nature which may be briefly described as follows: In one system the potential of a point or region of the earth is varied by imparting to it intermittent or alternating electrifications through one of the terminals of a suitable source of electrical disturbances, which to heighten the effect has its other terminal connected to an insulated body, preferably of large surface and at an elevation. The electrifications communicated to the earth spread in all directions through the same, reaching a distant circuit, which generally has its terminals arranged and connected similarly to those of the transmitting source and operates upon a highly-sensitive receiver. Another method is based upon the fact that the atmospheric air, which behaves as an excellent insulator to currents generated by ordinary apparatus, becomes a conductor under the influence of currents or impulses of enormously high electromotive force which I have devised means for generating. By such means air strata, which

are easily accessible, are rendered available for the production of many desired effects at distances, however great. This method, furthermore, allowed advantage to be taken of many of those improvements which are practicable in the ordinary systems of transmission involving the use of a metallic conductor.

在我提交的几个申请和授予我的专利中，我已经公开了实现这种性质的结果的其他方法，可以简要描述如下：在一个系统中，大地的某一点或某一区域的电位是通过适当的电扰动源的一个终端向其施加间歇或交变的电流来改变的，为了提高效果，电扰动源的另一个终端连接到一个被绝缘体上，该被绝缘体最好具有较大的表面并位于一个高处。传到大地的电流通过大地向四面八方传播，到达一个远距离的电路，该电路的终端一般与发射源的终端有着相似的布局 and 连接，并通过一个高灵敏度的接收器工作。另一种方法是基于这样一个事实，即对于普通设备产生的电流表现为一种优秀绝缘体的大气空气在非常高的电动势的电流或脉冲的影响下变成一种导体，我已经设计了产生这种极高电动势的工具。通过这种工具，容易接近的空气层可被用于在不同距离上产生许多所需的效果，无论距离有多远。此外，这种方法允许利用在涉及使用金属导体的普通传输系统中可行的许多改进。

Obviously whatever method be employed it is desirable that the disturbances produced by the transmitting apparatus should be as powerful as possible, and by the use of certain forms of high-frequency apparatus which I have devised and which are now well known important practical advantages are in this respect secured. Furthermore, since in most cases the amount of energy conveyed to the distant circuit is but a minute fraction of the total energy emanating from the source it is necessary for the attainment of the best results that whatever the character of the receiver and the nature of the disturbances as much as possible of the energy conveyed should be made available for the operation of the receiver, and with this object in view I have heretofore, among other means, employed a receiving-circuit of high self-induction and very small resistance and of a period such as to vibrate in synchronism with the disturbances, whereby a number of separate impulses from the source were made to cooperate, thus magnifying the effect exerted upon and insuring the action of the receiving device. By these means decided advantages have been secured in many instances; but very often the improvement is either not applicable at all, or if so the gain is very slight. Evidently when the source is one producing a continuous pressure or delivering impulses of long duration it is impracticable to magnify the effects in this manner, and when, on the other hand, it is one furnishing short impulses of extreme rapidity of succession the advantage obtained in this way is insignificant, owing to the radiation and the unavoidable frictional waste in the receiving-circuit. These losses reduce greatly both the intensity and the number of the cooperative impulses, and since the initial intensity of each of these is necessarily limited only an insignificant amount of energy is thus made available for a single operation of the receiver. As this amount is consequently dependent on the energy conveyed to the receiver by one single impulse, it is evidently necessary to employ either a very large and costly and therefore objectionable transmitter or else to resort to the equally objectionable use of a receiving device too delicate and too easily deranged. Furthermore, the energy obtained through the cooperation of the impulses is in the form of extremely-rapid vibrations and because of this unsuitable for the operation of ordinary receivers, the more so as this form of energy imposes narrow restrictions in regard to the mode and time of its application to such devices. To overcome these and other limitations and disadvantages that have heretofore existed in such systems of transmission of signals or intelligence and to render possible an investigation of impulses or disturbances propagated through the natural media from any kind of source and their practical utilization for any purpose to which they are applicable, I have devised a novel method, which

I have described in a pending application filed June 24, 1899, Serial No. 721,790, and which, broadly stated, consists in effecting during any desired time interval a storage of energy derived from such impulses and utilizing the potential energy so obtained for operating a receiving device.

显然，无论采用什么方法，都希望由发射装置产生的扰动尽可能的强，并且通过使用我已经设计的并且现在众所周知的某些形式的高频装置，在这方面确保了重要的实际优点。此外，由于在大多数情况下，传送到远处电路的能量只是从源头发出的总能量的很小一部分，所以为了获得最佳结果，无论接收器的特性和扰动的性质如何，都应该使尽可能多的传送能量可用于接收器的操作，鉴于这个目的，我迄今为止在其他工具中采用了一个具有高自感和非常小的电阻的接收电路，且该电路的周期使其能与扰动同步振动，由此来自源头的许多单独的脉冲被迫协作，从而放大影响和确保接收设备的作用。通过这些工具，在许多情况下都获得了明显的优势；但很多时候，这种改进要么根本不适用，要么就算适用，收益也非常小。显然，当源头是一个产生连续压力或传递长时间脉冲的源头时，用这种方式放大效果是不切实际的，而另一方面，当源头是一个提供极端快速连续的短脉冲的源头时，由于辐射和接收电路中不可避免的摩擦损耗，以这种方式获得的优势也是微不足道的。这些损耗大大降低了协同脉冲的强度和数量，并且由于这些协同脉冲的每一个的初始强度必然是有限的，因此只有少量的能量可用于接收器的单次操作。由于这个量因此依赖于由一个单个脉冲传送到接收器的能量，显然有必要使用非常大，并且昂贵，因此令人讨厌的发射器，或者求助于同样令人讨厌的使用过于精密且太容易混乱的接收装置。此外，通过脉冲协作获得的能量是以极快振动的形式存在的，因此不适合普通接收器的操作，尤其是这种形式的能量对于应用此能量的设备的模式和时间有着严格的限制。为了克服迄今为止在这种信号或情报传输系统中存在的这些和其它限制和缺点，并使研究从任何种类的源头通过自然媒介传播的脉冲或扰动及其应用于任何目的的实际应用成为可能，我设计了一种新颖的方法，我在 1899 年 6 月 24 日提交的未决申请 721,790 中描述了这种方法，概括地说，这种方法包括在任何所需的时间间隔期间实现从这种脉冲中获得的能量的存储，并利用如此获得的势能来操作接收装置。

My present invention is intended for the same general purposes, and it comprises a modified method and apparatus by means of which similar results may be obtained.

我的发明旨在用于相同的普遍目的，并且它包括一种改进的方法和装置，通过该方法和装置可以获得类似的结果。

The chief feature which distinguishes my present from my former invention just referred to is that the energy stored is not, as in the former instance, obtained from the energy of the disturbances or effects transmitted from a distance, but from an independent source.

我现在的方法与以前的发明的方法的主要区别在于，储存的能量不是像在以前的例子中那样，从来自一个远处传输的扰动或影响的能量中获得，而是从一个独立的来源获得。

Expressed generally, my present method consists in charging a storage device with energy from an independent source controlling the charging of said device by the action of the effects or disturbances transmitted through the natural media and coincidentally using the stored energy for operating a receiving device.

总的来说，我的现在的方法在于利用来自一个独立源头的能量对一个存储设备进行充电，该

独立源通过自然媒介传输的效应或扰动的作用来控制所述设备的充电,并且同时使用存储的能量来操作一个接收设备。

A great variety of disturbances produced either by suitably-constructed transmitters or by natural causes are at present known to be propagated through the natural media, and there are also a variety of means or devices enabling energy to be stored, and in view of this I wish to say that I consider the utilization of any such disturbances and the employment of any of these means as within the scope of my present invention so long as the use of the general method hereinbefore stated is involved.

目前已知由适当构造的发射器或自然原因产生的各种各样的扰动可通过自然媒介传播,并且还有各种能够存储能量的工具或设备,鉴于此,我想说,我认为任何这种扰动的利用和任何这些工具的使用都在我的发明的范围内,只要涉及使用上文所述的通用方法。

The best way of carrying out my invention which I at present know is to store electrical energy obtained from a suitable electrical generator in a condenser and to control the storage on the application of this energy by means of a sensitive device acted upon by the effects or disturbances, and thereby cause the operation of the receiver.

我目前所知的实施我的发明的最佳方式是将从合适的发电机获得的电能存储在电容器中,并通过受影响或扰动作用的一个敏感装置控制该能量的存储,从而使接收器工作。

In the practical application of this method I usually proceed as follows: At any point where I desire to investigate or to utilize for any purpose effects or disturbances propagated through the natural media from any kind of source I provide a suitable generator of electricity—as, for example, a battery and a condenser—which I connect to the poles of the generator in series with a sensitive device capable of being modified in its electrical resistance or other property by the action of the disturbances emitted from the source. To the terminals of the condenser I connect the receiver which is to be operated in series with another device of suitable construction which performs the function of periodically discharging the condenser through the receiver at and during such intervals of time as may be best suitable for the purpose contemplated. This latter device may merely consist of two stationary electrodes separated by a feeble dielectric layer of minute thickness, but sufficient to greatly reduce or practically interrupt the current in the circuit under normal conditions, or it may comprise terminals one or more of which are movable and actuated by any suitable force and are adapted to be brought into and out of contact with each other in any convenient manner. The sensitive device may be any of the many devices of this kind which are known to be affected by the disturbances, impulses, or effects propagated through the media, and it may be of such a character that normally—that is, when not acted upon—it entirely prevents the passage of electricity from the generator to the condenser, or it may be such that it allows a gradual leaking through of the current and a charging of the condenser at a slow rate. In any case it will be seen that if the disturbances, of whatever nature they may be, cause an appreciable diminution in the electrical resistance of the sensitive device the current from the battery will pass more readily into the condenser, which will be charged at a more rapid rate, and consequently each of its discharges through the receiver, periodically effected by the special device before referred to which performs this function, will be stronger than normally—that is, when the sensitive device is not acted upon by the disturbances. Evidently, then, if the receiver be so adjusted that it does not respond to the comparatively feeble normal discharges of the condenser, if they should occur, but only to those stronger ones which

take place upon the diminution of the resistance of the sensitive device, it will be operated only when this device is acted upon by the disturbances, thus making it possible to investigate and to utilize the latter for any desired purpose.

在这种方法的实际应用中,我通常如下进行:在我希望调查或利用通过自然媒介传播的任何种类来源的影响或扰动以达到任何目的的任何点上,我配备了一台合适的发电机——例如,一个电池和一个电容器——我将它与发电机的电极和一个敏感装置串联,该敏感装置能够通过从源头发出的扰动的作用来改变其电阻或其他属性。我将接收器连接到电容器的不同终端,该接收器将与另一个具有合适结构的装置串联操作,该装置以最适合预期目的的时间间隔或在最适合预期目的的时间间隔期间执行通过接收器周期性地使电容器放电的功能。后一种装置可以仅由两个静态电极组成,这两个固定电极由微小厚度的弱介电层隔开,但是足以在正常条件下极大地削弱或实际上中断电路中的电流,或者它可以包含终端,其中一个或多个终端是可移动的,并且由任何合适的力驱动,并且适于以任何方便的方式彼此接触和脱离接触。敏感装置可以是已知的受扰动、脉冲或通过媒介传播的效应所影响的许多这类装置中的任何一种,并且它可以具有这样的特性,即在正常情况下——也就是说,当不被施加作用时——它完全阻止电力从发电机传递到电容器,或者它可以是这样的,即它允许电流逐渐泄漏并以缓慢的速率对电容器充电。在任何情况下,可以看出,如果扰动(无论其性质如何)导致敏感设备的电阻明显减小,则来自电池的电流将更容易进入电容器,电容器将以一个更快的速率充电,因此其通过接收器的每一次放电(由前面提到的执行该功能的特殊设备周期性地影响)将比正常情况更强,也就是说,当敏感设备没有受到扰动作用时。显然,那么,如果接收器被调整到不能响应电容器的相对微弱的正常放电,如果它们应该发生,但只响应那些在敏感装置的电阻减小时发生的更强的放电,它将只在这个设备受到扰动时运行,使得研究和利用后者用于任何预期的目的成为可能。

The general principle underlying my invention and the operation of the various devices used will be clearly understood by reference to the accompanying drawings, in which—

通过参考附图,将会清楚地理解本发明的基本原理和所使用的各种设备的操作,其中—

Figure 1 is a diagram illustrating a typical arrangement of apparatus which may be used in carrying my method into practice, and Figs. 2, 3, 4, and 5 similar diagrams of modified arrangements of apparatus for the same purpose.

图1是说明可用于实施我的方法的装置的典型布置的示意图,图2、3、4和5是用于相同目的的装置的改进布置的示意图。

In Fig. 1, C is a condenser, to the terminals T and T' of which is connected a charging-circuit including a battery B, a sensitive device a, and a resistance r, all connected in series, as illustrated. The battery should be preferably of very constant electromotive force and of an intensity carefully determined to secure the best results. The resistance r, which may be a frictional or an inductive one, is not absolutely necessary; but it is of advantage to use it in order to facilitate adjustment, and for this purpose it may be made variable in any convenient and preferably continuous manner. Assuming that the disturbances which are to be investigated or utilized for some practical end are rays identical with or resembling those of ordinary light, the sensitive device a may be a selenium cell properly prepared, so as to be highly susceptible to the influence of the rays, the action of which should be intensified by the use of a reflector

A, shown in the drawings. It is well known that when cells of this kind are exposed to such rays of greatly-varying intensity they undergo corresponding modifications of their electrical resistance; but in the ways they have been heretofore used they have been of very limited utility. In addition to the circuit including the sensitive device or cell a another circuit is provided, which is likewise connected to the terminals 'T T' of the condenser. This circuit, which may be called the "receiving-circuit," includes the receiver R and in series with it a device d, before referred to, which performs the duty of periodically discharging the condenser through the receiver. It will be noted that, as shown in Fig. 1, the receiving-circuit is in permanent connection with the battery and condenser terminal T, and it should be stated that it is sometimes desirable to entirely insulate the receiving-circuit at all times except the moments when the device d operates to discharge the condenser, thus preventing any disturbing influence which might otherwise be caused in this circuit by the battery or the condenser during the period when the receiver should not be acted upon. In such a case two devices, as d, may be used—one in each connection from the condenser to the receiving-circuit—or else one single device of this kind, but of a suitably-modified construction, so that it will make and break simultaneously and at proper intervals of time both of the connections of this circuit with the condenser T and T'.

在图 1 中, C 是一个电容器, 它的终端 T 和 T' 连接到一个充电电路, 该充电电路包括一个电池 B、一个敏感装置 a 和一个电阻 r, 如图所示, 它们都串联连接。该电池应该优选地具有非常恒定的电动势和一个仔细确定的强度, 以确保最佳结果。电阻 r 可以是一个摩擦电阻或电感电阻, 但并不是绝对必要的; 但是使用它是有利的, 以便于调节, 并且为此目的, 它可以被制成以任何方便的并且优选连续的方式变化。假设要研究或用于某些实际目的的扰动是与普通光相同或相似的光线, 敏感器件 a 可以是适当制备的一个硒电池, 以便对光线的影响高度敏感, 其作用应该通过使用一个反射器 A 来加强, 如图所示。众所周知, 当这种电池暴露于这种强度变化很大的射线时, 它们的电阻会发生相应的变化; 但是在迄今为止它们的使用方式中, 它们的效用非常有限。除了包含有敏感器件或电池 a 的电路之外, 还提供了另一个电路, 它同样连接到电容器的终端 T T'。该电路可以被称为“接收电路”, 包括接收器 R 和与其串联的一个装置 d, 该装置通过该接收器执行周期性地使电容器放电的任务。应该注意的是, 如图 1 所示, 接收电路与电池和电容器终端 T 永久连接, 并且应该指出的是, 除了装置 d 操作使电容器放电的时刻之外, 有时希望在所有时间完全隔离接收电路, 从而防止在接收器不被操作的期间, 电池或电容器可能在该电路中引起的任何扰动影响。在这种情况下, 可以使用两个装置, 如 d——从电容器到接收电路的每个连接中都有一个——或者这种类型的一个单独的装置, 但是具有适当修改的结构, 这样它可以在适当的时间间隔同时接通和断开该电路与电容器 T 和 T' 的两个连接。

From the foregoing the operation of the apparatus as illustrated in Fig. 1 will be at once understood. Normally—that is, when it is not influenced by the rays at all or very slightly—the cell a being of a comparatively high resistance permits only a relatively feeble current to pass from the battery into the condenser, and hence the latter is charged at too slow a rate to accumulate during the time interval between two succeeding operations of the device d sufficient energy to operate the receiver or, generally speaking, to produce the required change in the receiving-circuit. This condition is readily secured by a proper selection and adjustment of the various devices described, so that the receiver will remain unresponsive to the feeble discharges of the condenser which may take place when the cell a is acted upon but slightly or not at all by the rays or disturbances; but if now new rays are permitted to fall upon the cell or if the intensity of those already acting upon it be increased by any cause then its resistance will be diminished and the condenser will be charged by the battery at a more rapid rate, enabling

sufficient potential energy to be stored in the condenser during the period of inaction of the device d to operate the receiver or to bring about any desired change in the receiving-circuit when the device d acts. If the rays acting upon the cell or sensitive device a are varied or intermitted in any arbitrary manner, as when transmitting intelligence in the usual way from a distant station by means of short and long signals, the apparatus may readily be made to record or to enable an operator to read the message, since the receiver, supposing it to be an ordinary magnetic relay, for example, will be operated by each signal from the sending-station a certain number of times having some relation to the duration of each signal. It will be readily seen, however, that if the rays are varied in any other way, as by impressing upon them changes in intensity, the succeeding condenser discharges will undergo corresponding changes in intensity, which may be indicated or recorded by a suitable receiver and distinguished irrespectively of duration.

根据前述内容，将立刻理解如图 1 所示的设备 d 的操作。正常情况下——也就是说，当它完全不受射线影响或非常轻微地受射线影响时——具有相对较高电阻的电池 a 只允许相对较弱的电流从电池进入电容器，因此电容器以太慢的速率充电，以至于在设备 d 的两个连续操作之间的时间间隔期间不能积累足够的能量来操作接收器，或者一般来说，不能在接收电路中产生所需的变化。这一条件很容易通过所述各种设备的一个适当选择和调整来保证，因此接收器将对电容器的微弱放电保持无响应，这种微弱放电可以在电池 a 受到光线或扰动作用时发生，但这种作用太轻微或根本毫无作用；但是如果现在允许新的射线落在电池上，或者如果那些已经作用在电池上的射线的强度由于任何原因而增加，那么它的电阻将减小，并且电容器将由电池以更快的速率充电，使得在设备 d 不工作期间有足够的势能存储在电容器中，以操作接收器，或者当设备 d 工作时在接收电路中产生任何期望的变化。如果作用在电池或敏感装置 a 上的射线以任意方式变化或中断，如当以通常的方式通过短信号和长信号从远处的站发送信息时，该装置可以容易地记录或使操作者能够阅读信息，因为接收器，例如假设它是一个普通的磁继电器，将由来自发送站的每个信号操作一定次数，这与每个信号的持续时间有一定关系。然而，很容易看出，如果射线以任何其他方式变化，如通过在其上施加强度变化，随后的电容器放电将经历相应的强度变化，这可以由合适的接收器指示或记录，并与持续时间无关。

With reference to Fig. 1, it may be useful to state that the electrical connections of the various devices illustrated may be made in many different ways. For instance, the sensitive device instead of being in series, as shown, may be in a shunt to the condenser, this modification being illustrated in Fig. 3, in which the devices already described are indicated by similar letters to correspond with those of Fig. 1. In this case it will be observed that the condenser which is being charged from the battery B through the resistance r, preferably inductive and properly related to the capacity of the condenser, will store less energy when the sensitive device a is energized by the rays and its resistance thereby diminished. The adjustment of the various instruments may then be such that the receiver will be operated only when the rays are diminished in intensity or interrupted and entirely prevented from falling upon the sensitive cell, or the sensitive device may be placed, as shown in Fig. 4, in a shunt to the resistance r or inserted in any suitable way in the circuit containing the receiver—for example, as illustrated in Fig. 5—in both of which figures the various devices are lettered to correspond with those in Fig. 1, so that the figures become self-explanatory. Again, the several instruments may be connected in the manner of a Wheatstone bridge, as will be hereinafter explained with reference to Fig. 2, or otherwise connected or related; but in each case the sensitive device will have the same duty to perform—that is, to control the energy stored and utilized in some suitable way for causing the operation of the receiver in

correspondence with the intermittence or variations of the effects or disturbances, and in each instance by judicious selection of the devices and careful adjustment the advantages of my method may be more or less completely secured. I find it preferable, however, to follow the plan which I have illustrated and described.

参考图 1, 说明所示的各种设备的导电连接可以以许多不同的方式进行可能是有用的。例如, 如图所示, 敏感装置不是串联的, 而是可以与电容器并联, 这种修改在图 3 中示出, 其中已经描述的装置用与图 1 中对应的类似字母表示。在这种情况下, 可以观察到, 当敏感装置 a 被射线激励时并且它的电阻明显降低, 这时通过电阻 r 从电池 B 充电的电容器将存储较少的能量, 电阻 r 最好是电感性的, 并与电容器的容量适当相关。然后, 各种仪器的调整可以是这样的, 即接收器将仅在射线强度减弱或被中断并完全被阻止落在敏感电池上时才工作, 或者敏感装置可以如图 4 所示被放置在电阻 r 的分流器中, 或者以任何适合的方式被插入包含了接收器的电路中——例如, 如图 5 所示——在这两个图中, 各种装置被标上字母以与图 1 中的对应, 从而这些图变得不言而喻。同样, 几个仪器可以以惠斯通电桥的方式连接, 如将在下文中参考图 2 解释的, 或者以其他方式连接或相关; 但在每一种情况下, 敏感设备将有相同的职责来执行——也就是说, 以某种适当的方式控制能量的存储和利用, 使接收器的操作与影响或扰动的间断性或变化相对应, 在每一种情况下, 通过明智地选择设备和仔细调整, 可以或多或少完全确保我的方法的优点。然而, 我发现更好的是遵循我已经说明和描述的方案。

It will be observed that the condenser is an important element in the combination. I have shown that by reason of its unique properties it greatly adds to the efficiency of this method. It allows the energy accumulated in it to be discharged instantaneously, and therefore in a highly-effective manner. It magnifies in a large degree the current supplied from the battery, and owing to these features it permits energy to be stored and discharged at practically any rate desired, and thereby makes it possible to obtain in the receiving-circuit very great changes of the current strength by impressing upon the battery-current very small variations. Other means of storage possessing these characteristics to a useful degree may be employed without departing from the broad spirit of my invention; but I prefer to use a condenser, since in these respects it excels any other storage device of which I have knowledge. In Fig. 2 a modified arrangement of apparatus is illustrated which is particularly adapted for the investigation and utilization of very feeble impulses or disturbances, such as may be used in conveying signals or producing other desired effects at very great distances. In this case the energy stored in the condenser is passed through the primary of a transformer the secondary circuit of which contains the receiver, and in order to render the apparatus still more suitable for use in detecting feeble impulses in addition to the sensitive device which is acted upon by the impulses another such device is included in the secondary circuit of the transformer. The scheme of connections is in the main that of a Wheatstone bridge the four branches of which are formed by the sensitive device a and resistances L , L' , and L'' , all of which should be preferably inductive and also adjustable in a continuous manner or at least by very small steps. The condenser C' , which is generally made of considerable capacity, is connected to two opposite points of the bridge, while a battery B , in series with a continuously-adjustable non-inductive resistance r' , is connected to the other pair of opposite points, as usual. The four resistances included in the branches of the bridge—namely, a , L , L' , and L'' —are of a suitable size and so proportioned that under normal conditions—that is, when the device a is not influenced at all or only slightly by the disturbances—there will be no difference of potential or in any case the minimum of the same at the terminals T and T' of the condenser. It is assumed in the present instance that the disturbances to be investigated or

utilized are such as will produce a difference of electric potential, however small, between two points or regions in the natural media—as the earth, the water, or the air—and in order to apply this potential difference effectively to the sensitive device the terminals of the same are connected to two plates P and P', which should be of as large a surface as practicable and so located in the media that the largest possible difference of potential will be produced by the disturbances between the terminals of the sensitive device. This device is in the present case one of familiar construction, consisting of an insulating-tube, which is indicated by the heavy lines in the drawings and which has its ends closed tightly by two conducting-plugs with reduced extensions, upon which bear two brushes b b, through which the currents are conveyed to the device. The tubular space between the plugs is partially filled with a conducting sensitive powder, as indicated, the proper amount of the same and the size of its grains being determined and adjusted beforehand by experiment. This tube I rotate by clockwork or other means at a uniform and suitable rate of speed, and under these conditions I find that this device behaves toward disturbances of the kind before assumed in a manner similar to that of a stationary cell of selenium toward rays of light. Its electrical resistance is diminished when it is acted upon by the disturbances and is automatically restored upon the cessation of their influence. It is of advantage to employ round grains of powder in the tube, and in any event it is important that they should be of as uniform size and shape as possible and that provision should be made for maintaining an unchanging and very dry atmosphere in the tube. To the terminals T and T' of the condenser C' is connected a coil p, usually consisting of a few turns of a conductor of very small resistance, which is the primary of the transformer before referred to, in series with a device d, which effects the discharge of the condenser through the coil p at predetermined intervals of time. In the present case this device consists of a cylinder made partly of conducting and partly of insulating material e and e', respectively, which is rotated at the desired rate of speed by any suitable means. The conducting part e is in good electrical connection with shaft S and is provided with tapering segments, as f, upon which slides a brush k, which should preferably be capable of longitudinal adjustment along the cylinder. Another brush b', which is connected to the condenser-terminal T', being arranged to bear upon the shaft S, it will be seen that whenever the brush k comes in contact with a conducting-segment f the circuit including the primary p will be completed and the condenser, if energized, discharged through the same. By an adjustment of the speed of rotation of the cylinder and a displacement of the brush k along the axis of the same the circuit may be made to open and close in as rapid succession and remain open or closed during such intervals of time as may be desired. In inductive relation to the primary p is a secondary coil s, usually of much thinner wire and of many more turns than the former, to which are connected in a series a receiver R, (illustrated as an ordinary magnetic relay,) a continuously-adjustable non-inductive resistance r", a battery B' of a properly determined and very constant electromotive force, and finally a sensitive device a' of the same or similar construction as a, which is likewise rotated at a uniform speed and which with its brushes b" b" closes the secondary circuit. The electromotive force of the battery B' is so graduated by means of the adjustable resistance r" that the dielectric layers in the sensitive device a' are strained very nearly to the point of breaking down and give way upon a slight increase of the electrical pressure on the terminals of the device. It will of course be understood that the resistance r" is used mainly because of convenience and that it may be dispensed with, in which case the adjustment may be effected in many other ways, as by determining the proper amount or coarseness of the sensitive powder or by varying the distance apart of the metallic plugs in the ends of the tube. The same may be said of the resistance r', which is in series with the battery B and serves to graduate the force of the latter, so that the dielectric layers of the sensitive device a are subjected to a similar strain and maintained in a state of delicate poise. The various instruments being connected and adjusted in the manner described,

it will now be readily seen from the foregoing that under normal conditions, the device *a* being unaffected by the disturbances, or practically so, and there being no or only a very insignificant amount of energy stored in the condenser, the periodical closure of the primary circuit of the transformer through the operation of the device *d* will have no appreciable effect upon the primary coil *p*, and hence no currents will be generated in the secondary coil *s*, at least not such as would disturb the state of delicate balance existing in the secondary circuit including the receiver, and therefore the latter will not be actuated by the battery *B'*; but when, owing to the disturbances or impulses propagated through the media from a distant source, an additional electromotive force, however small, is created between the terminals of the device *a* the dielectric layers in the same, unable to support the increased strain, give way and allow the current of the battery *B* to pass through, thus causing a difference of potential at the terminals *T* and *T'* of the condenser. A sufficient amount of energy being now stored in this instrument during the time interval between each two succeeding operations of the device *d*, each closure of the primary circuit by the latter results in the passage of a sudden current impulse through the coil *p*, which induces a corresponding current of relatively high electromotive force in the secondary coil *s*. Owing to this the dielectric in the device *a'* gives way, and the current of the battery *B'* being allowed to pass the receiver *R* is operated, but only for a moment, since by the rotation of the devices *a*, *a'*, and *d*, which may be all driven from the same shaft, the original conditions are restored, assuming, of course, that the electromotive force set up by the disturbances at the terminals of the sensitive device *a* is only momentary or of a duration not longer than the time of closure of the primary circuit; otherwise the receiver will be actuated a number of times and so long as the influence of the disturbances upon the device *a* continues. In order to render the discharged energy of the condenser more effective in causing the operation of the receiver, the resistance of the primary circuit should be very small and the secondary coil *s* should have a number of turns many times greater than that of the primary coil *p*. It will be noted that since the condenser under the above assumption is always charged in the same direction the strongest current impulse in the secondary coil, which is induced at the moment when the brush *k* comes in contact with segment *f*, is also of unchanging direction, and for the attainment of the best results it is necessary to connect the secondary coil so that the electromotive force of this impulse will be added to that of the battery and will momentarily strengthen the same. However, under certain conditions, which are well understood by those skilled in the art, the devices will operate whichever way the secondary be connected. It is preferable to make the inductive resistance *L* and *L'* relatively large, as they are in a shunt to the device *a* and might if made too small impair its sensitiveness. on the other hand, the resistance *L''* should not be too large and should be related to the capacity of the condenser and the number of makes and breaks effected by the device *d* in well-known ways. Similar considerations apply, of course, to the circuits including the primary *p* and secondary *s*, respectively.

可以看出，电容器是组合中的一个重要组件。我已经表明，由于其独特的性质，它大大增加了这种方法的效率。它允许积聚在其中的能量瞬间释放，因此以高效的方式释放。它在很大程度上放大了电池提供的电流，并且由于这些特征，它允许能量以实际上任何期望的速率存储和放电，并且由此使得通过在电池电流上施加非常小的变化而在接收电路中获得电流强度的非常大的变化成为可能。在不脱离本发明的广义精神的情况下，可以使用在有用程度上拥有这些特征的其他存储工具；但我更喜欢使用电容器，因为在这些方面，它优于我所知道的其他任何存储设备。在图 2 中，展示出了装置的一个改进布置，其特别适于研究和利用非常微弱的脉冲或扰动，例如可以用于在非常远的距离上传送信号或产生其他期望的效果。在这种情况下，储存在电容器中的能量经过一个变压器的初级，变压器的次级电路包含接收器，为了使该设备更适合用于检测微弱的脉冲，除了由脉冲作用的敏感装置之外，在变压器的次

级电路中还包括另一个这样的装置。连接方案主要是一个惠斯通电桥，惠斯通电桥的四个分支由敏感器件 a 和电阻 L 、 L' 和 L'' 形成，所有这些最好是电感性的，并且也可以以连续的方式或至少以非常小的步长进行调节。通常由相当大的电容量制成的电容器 C' 连接到电桥的两个相对点，而与连续可调的无感电阻 r' 串联的电池 B 通常连接到另一对相对点。电桥支路中包含的四个电阻(即 a 、 L 、 L' 和 L'')具有适当的大小和比例，使得在正常情况下(即，当设备 a 完全不受扰动影响或仅轻微受影响影响时)，在电容器的终端 T 和 T' 处不会有电位差，或者在任何情况下电位差最小。在本实例中，假设待研究或待利用的扰动将在自然媒介(如大地、水或空气)中的两点或区域之间产生电势差，无论该电势差有多小，并且为了将该电势差有效地施加到敏感设备 a ，该设备的终端分别连接到两个板 P 和 P' ，其应当具有一个尽可能大的表面，并且位于媒介中，使得敏感装置的终端之间的扰动将产生最大可能的电势差。在本例中，这种装置是一种常见的结构，由一个绝缘管组成，绝缘管在图中用粗线表示，其端部由两个导电塞紧密封闭，导电塞具有减小的延伸部分，导电塞上带有两个电刷 b 、 b' ，电流通过电刷 b 、 b' 传送到装置。如图所示，导电塞之间的管状空间部分填充有导电敏感粉末，导电敏感粉末的适当量及其颗粒的尺寸通过实验预先确定和调整。我旋转发条或其他工具让这个管处在一个均速的和适当的速度，在这些条件下，我发现这个装置对前面假设的那种扰动的反应方式类似于一个静态的硒电池对光线的反应方式。当受到扰动作用时，它的电阻减小，当扰动停止时，它的电阻自动恢复。在管中使用圆形粉末颗粒是有优势的，并且在任何情况下，重要的是它们应该具有尽可能均匀的尺寸和形状，并且应该采取措施来保持管中不变的和非常干燥的环境。电容器 C' 的终端 T 和 T' 与一个线圈 p 相连，线圈 p 通常由几匝电阻很小的导体组成，它是上述变压器的初级，与装置 d 串联，装置 d 以预定的时间间隔通过线圈 p 使电容器放电。在这种情况下，该装置包含一个圆筒，一部分由导电材料 c 和一部分由绝缘材料 c' 制成，该圆筒通过任何合适的工具以所需的速度旋转。导电部分 c 与轴 S 具有良好的电连接，并配有锥形分段 f ，一个电刷 k 在锥形分段 f 上滑动，电刷 k 最好能够沿圆筒纵向调节。另一个电刷 b'' ，倚靠在轴 S 上，连接到电容器终端 T' 上，可以看到，每当电刷 k 与导电分段 f 接触时，包含初级线圈 p 的电路将被接通，电容器如果已充电，就会通过该电路放电。通过调节圆筒的转速和刷子 k 沿其轴线的位移，可以使电路快速连续地断开和闭合，并在所需的时间间隔期间保持断开和闭合。与初级线圈 p 成感应关系的是次级线圈 s ，通常具有比初级线圈细得多的导线和多得多的匝数，初级线圈 p 串联有接收器 R (图示为普通的磁继电器)、一个连续可调的无感电阻 r'' 、一个具有适当确定的且非常恒定的电动势的电池 B' ，以及最后具有与 a 相同或相似结构的敏感装置 a' ，敏感装置 a' 同样以均匀的速度旋转，并且利用其电刷 b'' 闭合次级电路。电池 B' 的电动势通过可调电阻 r'' 逐渐增加，使得敏感装置 a' 中的介电层的应变非常接近于击穿点，并且在该装置终端上的电压稍微增加时就会击穿。当然可以理解，使用电阻 r'' 主要是为了方便，并且可以省去电阻 r'' ，在这种情况下，可以通过许多其它方式来实现调节，例如通过确定适合量或粗糙度的敏感粉末，或者通过改变管子端部的金属塞之间的距离。电阻 r' 也是如此，它与电池 B 串联，用于以这样的方式增加电池 B 的强度，使得敏感装置 a 的介电层受到类似的应变，并保持在一微妙平衡状态。以所述方式连接和调节各种仪器，现在从前述内容中可以容易地看出，在正常条件下，装置 a 不受干扰的影响，或者实际上如此，并且在电容器中没有或者只有非常少量的能量存储，通过装置 d 的操作，变压器的初级电路的周期性闭合对初级线圈 p 没有明显的影响，因此在次级线圈 s 中不会产生电流，至少不会干扰包括接收器在内的次级电路中存在的微妙平衡状态，因此后者不会被电池 B' 激励；但是，当由于从远处源头通过媒介传播的扰动或脉冲，在装置 a 的终端之间产生一个额外的电动势时，无论该电动势多么小，该装置中的电介质层都不能承受增加的应变，从而使电池 B 的电流通过，从而在电容器的终端 T 和 T' 处产生电位差。现在，在设备 d 的每两次连续操作之间的时间间隔期间，足够量的能量存储在该仪器中，后者每次闭合初级电路 d 都会导致突然的电流脉冲通过线圈 p ，这会引起次级线圈 s 中

相应的具有较高电动势的电流。由于这一点，装置 a' 中的电介质让出通路，电池 B' 的电流被允许通过接收器 R 来操作，但这只是一个瞬间，因为通过装置 a、a' 和 d 的旋转，它们都是由同一轴驱动的，原始状态被恢复，当然，假设由敏感装置 a 的终端处的扰动建立的电动势只是瞬间的或持续时间不长于初级电路闭合的时间；否则，只要扰动对设备 a 的影响持续，接收器将被启动多次。为了使电容器释放的能量更有效地使接收器工作，初级电路的电阻应该非常小，次级线圈 s 的匝数应该比初级线圈 p 的匝数大许多倍。应该注意到，由于在上述假设下电容器总是以相同的方向充电，当电刷 k 与分段 f 接触时，在次级线圈中被感应出的最强电流脉冲也是不变的方向，为了获得最佳结果，有必要连接次级线圈，使得该脉冲的电动势将被加到电池的电动势上，并瞬间增强电池的电动势。然而，在本领域技术人员熟知的某些条件下，无论次级以何种方式连接，设备都将运行。最好使感性电阻 L 和 L' 相对较大，因为它们与设备 a 并联，如果太小，可能损害其灵敏度。另一方面，电阻 L' 不应该太大，并且应该与电容器的容量以及由装置 d 以众所周知的方式实现的接通和断开的次数有关。当然，类似的考虑也适用于分别包括初级 p 和次级 s 的电路。

By carefully observing well-known rules of scientific design and adjustment of the instruments the apparatus may be made extremely sensitive and capable of responding to the feeblest influences, thus making it possible to utilize impulses or disturbances transmitted from very great distances and too feeble to be detected or utilized in any of the ways heretofore known, and on this account the method here described lends itself to many scientific and practical uses of great value. Obviously the character of the devices and the manner in which they are connected or related may be greatly varied without departing from the spirit of my invention.

通过仔细观察装置的科学设计和调整的众所周知的规则，该装置可以非常敏感，能够响应最微弱的影响，从而使利用从非常远的距离传输的脉冲或扰动成为可能，这些脉冲或扰动太弱而不能以迄今已知的任何方式检测或利用，因此这里描述的方法有助于许多具有重大价值的科学和实际应用。显然，在不脱离本发明的精神的情况下，设备的特征以及它们连接或相关的方式可以有很大的变化。

What I claim as new, and desire to secure by Letters Patent, is—

我主张的是新的，并希望通过专利证书来保护的是—

1. The method hereinbefore described of utilizing effects or disturbances transmitted through the natural media, which consists in charging a storage device with energy from an independent source, controlling the charging of said device by the action of the effects or disturbances, and coincidentally using the stored energy for operating a receiving device.

1、上文描述的利用通过自然媒介传输的效应或扰动的方法，包括用来自一个独立电源的能量对存储设备充电，通过效应或扰动的作用控制所述设备的充电，并且同时使用存储的能量来操作接收设备。

2. The method hereinbefore described of utilizing effects or disturbances transmitted from a distant source, which consists in charging the storage device with electrical energy from an independent source, controlling the charging of said device by the action of the effects or disturbances, and coincidentally using the stored electrical energy for operating the receiving device.

2、上文描述的利用从远处源传输的效应或扰动的方法，包括用来自一个独立电源的电能对存储设备充电，通过效应或扰动的作用来控制所述设备的充电，并且同时使用存储的电能为操作接收设备。

3. The method hereinbefore described of utilizing effects or disturbances transmitted through the natural media, which consists in controlling, by means of such effects or disturbances, the charging of an electrical storage device from an independent source and discharging the stored energy through a receiving circuit.

3、上文所述的利用通过自然媒介传播的效应或扰动的方法，包括通过这种效应或扰动来控制一个独立电源对一个电存储装置的充电，并通过一个接收电路释放存储的能量。

4. The method hereinbefore described of utilizing effects or disturbances transmitted through the natural media, which consists in controlling, by means of such effects or disturbances, the charging of an electrical condenser from an independent source, and discharging the stored energy through a receiving-circuit.

4、上文描述的利用通过自然媒介传输的效应或扰动的方法，包括通过这种效应或扰动来控制从独立电源对一个电容器的充电，并通过一个接收电路释放被存储的能量。

5. The method hereinbefore described of utilizing effects or disturbances transmitted through the natural media, which consists in effecting a storage during any desired time interval and under control of such effects or disturbances, of energy derived from an independent source, and utilizing the potential energy so obtained for operating a receiving device.

5、上文所述的利用通过自然媒介传输的效应或扰动的方法，包括在任何期望的时间间隔期间，并在这种效应或扰动的控制下，实现从一个独立电源获得的能量的存储，并利用如此获得的势能来操作一个接收设备。

6. The method hereinbefore described of utilizing effects or disturbances transmitted through the natural media, which consists in effecting a storage, during any desired time interval and under the control of such disturbances or effects of electrical energy derived from an independent source, and utilizing the potential energy so obtained for operating a receiving device.

6、上文描述的利用通过自然媒介传输的效应或扰动的方法，包括在任何期望的时间间隔期间，在来自一个独立电源的电能的这种扰动或效应的控制下，实现存储，并利用如此获得的势能来操作一个接收设备。

7. The method hereinbefore described of utilizing effects or disturbances transmitted through the natural media, which consists in effecting a storage in a condenser during any desired time interval and under the control of such disturbances or effects, of electrical energy derived from an independent source, and utilizing the potential energy so obtained for operating a receiving device.

7、上文所述的利用通过自然媒介传输的效应或扰动的方法，包括在任何期望的时间间隔期间并在这种扰动或效应的控制下，在一个电容器中实现从一个独立电源获得的电能的存储，

并利用如此获得的势能来操作一个接收设备。

8. The method hereinbefore described of utilizing effects or disturbances transmitted through the natural media from a distant source, which consists in storing, during succeeding intervals of time determined by means of such effects or disturbances, electrical energy derived from an independent source, and utilizing the potential energy so accumulated to operate a receiving device.

8、上文描述的利用从一个远处电源通过自然媒介传输的效应或扰动的方法，包括在通过这种效应或扰动确定的连续时间间隔期间，存储从一个独立电源获得的电能，并利用如此积累的势能来操作一个接收设备。

9. The method hereinbefore described of utilizing effects or disturbances transmitted through the natural media from a distant source, which consists in storing in a condenser during succeeding intervals of time determined by means of such effects or disturbances, electrical energy derived from an independent source, and utilizing the potential energy so accumulated to operate a receiving device.

9、上文所述的利用从一个远处电源通过自然媒介传输的效应或扰动的方法，包括在通过这种效应或扰动确定的连续时间间隔期间，将来自一个独立电源的电能存储在电容器中，并利用如此积累的势能来操作接收装置。

10. The method hereinbefore described of utilizing effects or disturbances transmitted through the natural media from a distant source, which consists in storing, during succeeding intervals of time determined by means of such effects or disturbances, electrical energy derived from an independent source, and using, for periods of time predetermined as to succession and duration, the accumulated energy so obtained to operate a receiving device.

10、上文所述的利用从一个远处电源通过自然媒介传输的效应或扰动的方法，包括在通过这种效应或扰动确定的连续时间间隔期间存储从一个独立电源获得的电能，并在预定的连续和持续时间内使用如此获得的累积能量来操作一个接收装置。

11. The method hereinbefore described of utilizing effects or disturbances transmitted through the natural media from a distant source, which consists in storing in a condenser during succeeding intervals of time determined by means of such effects or disturbances, electrical energy derived from an independent source, and using, for periods of time predetermined as to succession and duration, the accumulated energy so obtained to operate a receiving device.

11、上文所述的利用从一个远处电源通过自然媒介传输的效应或扰动的方法，包括在通过这种效应或扰动确定的连续时间间隔期间，将从一个独立源获得的电能存储在电容器中，并在预定的连续和持续时间内，使用如此获得的累积能量来操作一个接收装置。

12. The method hereinbefore described of utilizing electrical effects or disturbances transmitted through the natural media from a distant source, which consists in effecting by means of such disturbances or effects a storage in a storage device of electrical energy derived from an independent source for periods of time corresponding in succession and duration to such disturbances or effects, and discharging the electrical energy so accumulated into or through a receiving device at predetermined

intervals of time.

12、上文所述的利用从一个远处电源通过自然媒介传输的电效应或扰动的方法，包括通过这种扰动或效应，在与这种扰动或效应连续和持续对应的时间段内，将来自一个独立电源的电存储存储在存储装置中，并以预定的时间间隔将如此积累的电存储释放到一个接收装置中或通过一个接收装置释放。

13. The method hereinbefore described of utilizing electrical effects or disturbances transmitted from a distant source, which consists in effecting by means of such disturbances or effects a storage in a condenser of electrical energy derived from an independent source for periods of time corresponding in succession and duration to such disturbances or effects, and discharging the electrical energy so accumulated into or through a receiving device at predetermined intervals of time.

13、上文所述的利用从一个远处电源传输的电效应或扰动的方法，包括通过这种扰动或效应在电容器中存储来自一个独立电源的电存储，存储的时间周期与这种扰动或效应的连续时间和持续时间相对应，并以预定的时间间隔将如此积累的电存储释放到一个接收装置中或通过一个接收装置释放。

14. The method hereinbefore described of utilizing electrical effects or disturbances transmitted from a distant source, which consists in producing, by means of such effects or disturbances, variations of resistance in a circuit including an independent electrical source and a device adapted to be charged with electrical energy therefrom, thereby causing the storage device to be charged with energy from such independent source, and using the potential electrical energy so accumulated to operate a receiving device.

14、上文所述的利用从一个远处电源传输的电效应或扰动的方法，包括通过这种效应或扰动，在包含一个独立电源和适于从中充电的一个装置在内的电路中产生电阻变化，从而使该存储装置从这种独立电源充电，并使用如此积累的电能来操作一个接收装置。

15. The method hereinbefore described of utilizing effects or disturbances transmitted through the natural media from a distant source, which consists in producing, by means of such effects or disturbances, variations of resistance in a circuit including an independent electrical source and a condenser, thereby causing the condenser to be charged with energy from the independent source, and using the potential electrical energy so accumulated to operate a receiving device.

15、上文所述的利用从一个远处电源通过自然媒介传输的效应或扰动的方法，包括通过这种效应或扰动在包含一个独立电源和一个电容器在内的电路中产生电阻变化，从而使电容器被来自该独立电源的能量充电，并使用如此积累的势能来操作一个接收设备。

16. The method hereinbefore described of utilizing effects or disturbances transmitted through the natural media from a distant source, which consists in causing, by means of such effects or disturbances, electrical energy from an independent source to be stored in a storage device, using the electrical energy so accumulated to operate a transformer and employing the secondary currents from such transformer to operate a receiving device.

16、上文所述的利用从一个远处电源通过自然媒介传输的效应或扰动的方法，包括通过这种效应或扰动使来自一个独立电源的电存储在一个存储设备中，使用如此积累的电来操作一个变压器，并使用来自这种变压器的次级电流来操作一个接收设备。

17. The method hereinbefore described of utilizing effects or disturbances transmitted through the natural media from a distant source, which consists in causing, by means of such effects or disturbances, electrical energy from an independent source to be stored in a condenser, using the electrical energy so accumulated to operate a transformer and employing the secondary currents from such transformer to operate a receiving device.

17、上文所述的利用从一个远处电源通过自然媒介传输的效应或扰动的方法，包括通过这种效应或扰动使来自一个独立电源的电存储在一个电容器中，使用如此积累的电来操作一个变压器，并使用来自这种变压器的次级电流来操作接收设备。

18. The method hereinbefore described of utilizing effects or disturbances transmitted through the natural media from a distant source, which consists in causing, by means of such disturbances, variations of resistance in a circuit including an independent source of electricity and a storage device and thereby causing the storage device to be charged from such independent source, discharging the energy so accumulated in the storage device through the primary of a transformer at predetermined intervals of time, and operating a receiver by the currents so developed in the secondary of the transformer.

18、上文所述的利用从一个远处电源通过自然媒介传输的效应或扰动的方法，包括通过这种扰动引起包含一个独立电源和一个存储装置在内的电路中的电阻变化，从而使存储装置从这种独立电源充电，以预定的时间间隔通过变压器的初级线圈释放存储装置中积累的能量，并通过变压器次级线圈中产生的电流操作一个接收器。

19. The method hereinbefore described of utilizing effects or disturbances transmitted through the natural media from a distant source, which consists in causing, by means of such disturbances, variations of resistance in a circuit including an independent source of electricity and a condenser and thereby causing the condenser to be charged from such independent source, discharging the energy so accumulated in the condenser through the primary of a transformer at predetermined intervals of time and operating a receiver by the currents so developed in the secondary of the transformer.

19、上文所述的利用从一个远处电源通过自然媒介传输的效应或扰动的方法，包括通过这种扰动引起包含一个独立电源和一个电容器在内的电路中的电阻变化，从而使该电容器从这种独立电源充电，以预定的时间间隔通过一个变压器的初级线圈释放该电容器中积累的能量，并通过该变压器次级线圈中产生的电流操作一个接收器。

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METHOD OF UTILIZING EFFECTS TRANSMITTED THROUGH NATURAL MEDIA.

(Application filed Aug. 1, 1899. Renewed May 29, 1901.)

(No Model.)

2 Sheets—Sheet 1.

Fig 1.

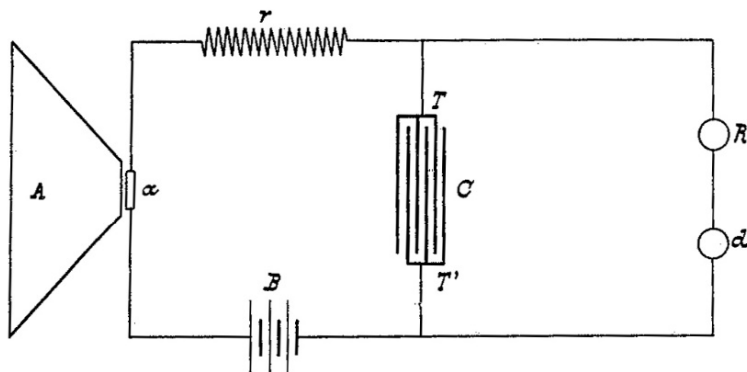
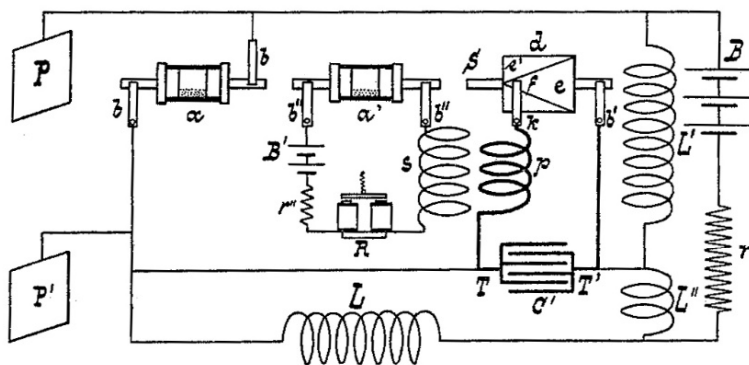


Fig 2.



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METHOD OF UTILIZING EFFECTS TRANSMITTED THROUGH NATURAL MEDIA.

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2 Sheets—Sheet 2.

Fig. 3

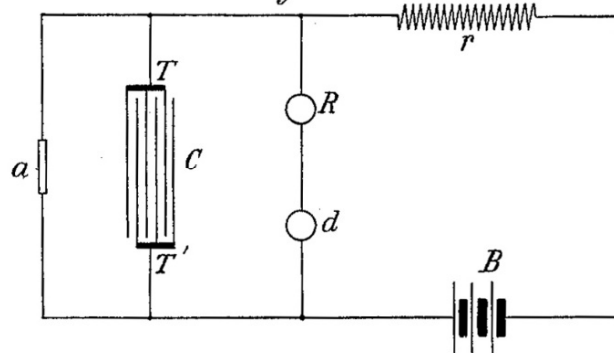


Fig. 4

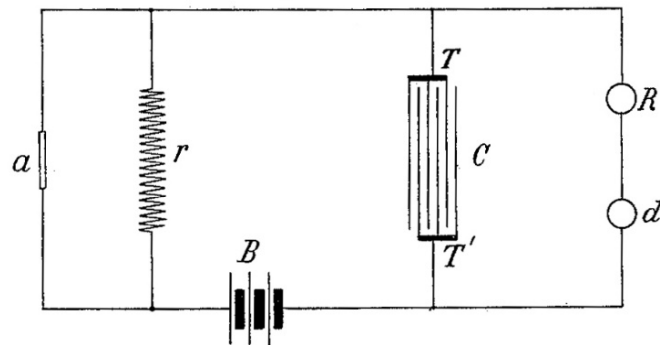
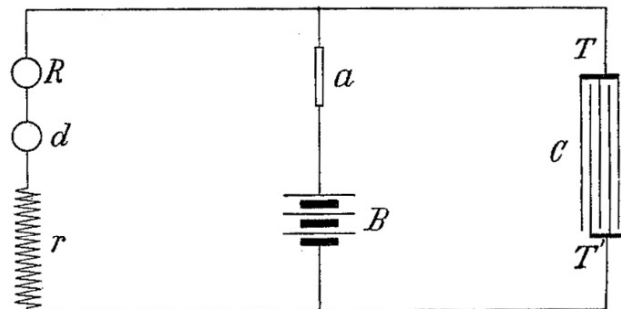


Fig. 5



Witnesses:

Raphael Jetter
Benjamin Miller

Nikola Tesla Inventor
by Ken. Page & Coopers Attys

APPARATUS FOR UTILIZING EFFECTS TRANSMITTED FROM A DISTANCE TO A RECEIVING DEVICE THROUGH NATURAL MEDIA.

利用通过自然媒介从远处传输到接收设备 的效果的装置

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SPECIFICATION forming part of Letters Patent No. 685,955, dated November 5, 1901.
Original application filed June 24, 1899, Serial No. 721,790. Divided and this application filed
September 8, 1899. Renewed May 29, 1901. Serial No. 62,317. (No model.)

该说明书形成了颁发于 1901 年 11 月 5 日编号为 685,955 的专利证书的一部分。
申请于 1899 年 6 月 24 日提交。1901 年 5 月 29 日更新。序列号 62,317。(没有模型)

To all whom it may concern:

致所有相关人士:

Be it known that I, NIKOLA TESLA, a citizen of the United States, residing at the borough of Manhattan, in the city, county, and State of New York, have invented certain new and useful Improvements in Apparatus for Utilizing Effects Transmitted from a Distance to a Receiving Device Through the Natural Media, of which the following is a specification, reference being had to the accompanying drawings, which form a part of the same.

众所周知，我，尼古拉·特斯拉，美国公民，居住纽约州纽约郡纽约市的曼哈顿区，在关于利用通过自然媒介从远处传输到接收设备的效果的装置方面已经发明了某种新的和有用的改进，以下是该发明一个说明书，必须参考随附的图纸，它已形成该说明书的一部分。

This application is a division of an application filed by me June 24, 1899, Serial No. 721,790, in which a method of utilizing effects or disturbances transmitted through the natural media from a distant source is described and made the subject of the claims. The invention of my present application consists in the apparatus hereinafter described and claimed, by the use of which the method claimed in my said prior application may be practiced and by means of which results hitherto unattainable may be secured.

本申请是由本人于 1899 年 6 月 24 日提交的序列号为 721,790 的申请的分立，其中描述了一种利用从远处源通过自然媒介传输的效应或扰动的方法，并成为权利主张的主题。我的本申

请的发明包括下文描述和要求主张的设备，通过使用该设备，可以实施在我的所述的先前申请中要求主张的方法，并且通过该设备可以获得迄今为止无法获得的结果。

Several ways or methods of transmitting electrical disturbances through the natural media and utilizing them to operate distant receivers are now known and have been applied with more or less success for accomplishing a variety of useful results. One of these ways consists in producing by a suitable apparatus rays or radiations—that is, disturbances—which are propagated in straight lines through space, directing them upon a receiving or recording apparatus at a distance, and thereby bringing the latter into action. This method is the oldest and best known, and has been brought particularly into prominence in recent years through the investigations of Heinrich Hertz. Another method consists in passing a current through a circuit, preferably one enclosing a very large area, inducing thereby in a similar circuit, situated at a distance, another current and affecting by the same in any convenient way a receiving device. Still another way, which has also been known for many years, is to pass in any suitable manner a current through a portion of the ground, as by connecting to two points of the same, preferably at a considerable distance from each other, the two terminals of a generator and to energize by a part of the current diffused through the earth a distant circuit, which is similarly arranged and grounded at two points widely apart and which is made to act upon a sensitive receiver. These various methods have their limitations, one, especially, which is common to all, being that the receiving circuit or instrument must be maintained in a definite position with respect to the transmitting apparatus, which often imposes great disadvantages upon the use of the apparatus.

通过自然媒介传输电扰动并利用它们来操作远程接收器的几种方式或方法现在是已知的，并且已经或多或少成功地应用于实现各种有用的结果。其中一种方法是通过一个合适的装置产生射线或辐射——即扰动——这些射线或辐射在空间中直线传播，将它们导向远处的接收或记录装置，从而使后者起作用。这种方法是最古老的，也是最广为人知的，最近几年，通过海因里希·赫兹的研究，这种方法变得尤为突出。另一种方法是使电流通过一个电路，最好是包围很大面积的一个电路，从而在位于远处的一个类似电路中感应出另一个电流，并以任何方便的方式影响一个接收装置。还有另一种方法，也是多年来已知的，是以任何合适的方式使电流通过一部分地面，例如将一个发电机的两个终端通过连接地面的两个点，最好是相距很远的两个点，并通过地面来扩散一部分电流来激励远处的一个电路，该电路类似于布置并在相距很远的两个点接地，这两个点作用在一个灵敏的接收器上。这些不同的方法都有其局限性，尤其是一个普遍存在的局限性，即接收电路或接收仪器必须保持在相对于发射设备的确定位置，这通常给设备的使用带来很大的缺点。

In several applications filed by me and patents granted to me I have disclosed other methods of accomplishing results of this nature, which may be briefly described as follows: In one system the potential of a point or region of the earth is varied by imparting to it intermittent or alternating electrifications through one of the terminals of a suitable source of electrical disturbances, which to heighten the effect has its other terminal connected to an insulated body, preferably of large surface and at an elevation. The electrifications communicated to the earth spread in all directions through the same, reaching a distant circuit, which generally has its terminals arranged and connected similarly to those of the transmitting source, and operates upon a highly-sensitive receiver. Another method is based upon the fact that the atmospheric air, which behaves as an excellent insulator to currents generated by ordinary apparatus, becomes a conductor under the influence of currents of impulses of enormously high electromotive force which I have devised means for generating. By such means air strata, which

are easily accessible, are rendered available for the production of many desired effects at distances, however great. This method, furthermore, allows advantage to be taken of many of those improvements which are practicable in the ordinary systems of transmission involving the use of a metallic conductor.

在我提交的几个申请和授予我的专利中,我已经公开了实现这种性质的结果的其他方法,可以简要描述如下:在一个系统中,大地的某一点或某一区域的电位是通过适当的电扰动源的一个终端向其施加间歇或交变的电流来改变的,为了提高效果,电扰动源的另一个终端连接到一个被绝缘体上,该被绝缘体最好具有较大的表面并位于一个高处。传到大地电流通过大地向四面八方传播,到达一个远距离的电路,该电路的终端一般与发射源的终端有着相似的布局 and 连接,并通过一个高灵敏度的接收器工作。另一种方法是基于这样一个事实,即对于普通设备产生的电流表现为一种优秀绝缘体的大气空气在非常高的电动势的电流或脉冲的影响下变成一种导体,我已经设计了产生这种极高电动势的工具。通过这种工具,容易接近的空气层可被用于在不同距离上产生许多所需的效果,无论距离有多远。此外,这种方法允许利用在涉及使用金属导体的普通传输系统中可行的许多改进。

Obviously whatever method be employed it is desirable that the disturbances produced by the transmitting apparatus should be as powerful as possible, and by the use of certain forms of high-frequency apparatus which I have devised and which are now well known important practical advantages are in this respect secured. Furthermore, since in most cases the amount of energy conveyed to the distant circuit is but a minute fraction of the total energy emanating from the source, it is necessary for the attainment of the best results that whatever the character of the receiver and the nature of the disturbances as much as possible of the energy conveyed should be made available for the operation of the receiver, and with this object in view I have heretofore, among other means, employed a receiving-circuit of high self-induction and very small resistance and of a period such as to vibrate in synchronism with the disturbances, whereby a number of separate impulses from the source were made to cooperate, thus magnifying the effect exerted upon and insuring the action of the receiving device. By these means decided advantages have been secured in many instances; but very often the improvement is either not applicable at all or if so the gain is very slight. Evidently when the source is one producing a continuous pressure or delivering impulses of long duration it is impracticable to magnify the effects in this manner, and when, on the other hand, it is one furnishing short impulses of extreme rapidity of succession the advantage obtained in this way is insignificant, owing to the radiation and the unavoidable frictional waste in the receiving-circuit. These losses reduce greatly both the intensity and the number of the cooperative impulses, and since the initial intensity of each of these is necessarily limited only an insignificant amount of energy is thus made available for a single operation of the receiver. As this amount is consequently dependent on the energy conveyed to the receiver by one single impulse, it is evidently necessary to employ either a very large and costly, and therefore objectionable transmitter, or else resort to the equally objectionable use of a receiving device too delicate and too easily deranged. Furthermore, the energy obtained through the cooperation of the impulses is in the form of extremely-rapid vibrations and because of this unsuitable for the operation of ordinary receivers, the more so as this form of energy imposes narrow restrictions in regard to the mode and time of its application to such devices. To overcome these and other limitations and disadvantages which have heretofore existed in such systems of transmission of signals or intelligence is the object of my invention, which comprises a novel form of apparatus for accomplishing these results.

显然,无论采用什么方法,都希望由发射装置产生的扰动尽可能的强,并且通过使用我已经

设计的并且现在众所周知的某些形式的高频装置，在这方面确保了重要的实际优点。此外，由于在大多数情况下，传送到远处电路的能量只是从源头发出的总能量的很小一部分，所以为了获得最佳结果，无论接收器的特性和扰动的性质如何，都应该使尽可能多的传送能量用于接收器的操作，鉴于这个目的，我迄今为止在其他工具中采用了一个具有高自感和非常小的电阻的接收电路，且该电路的周期使其能与扰动同步振动，由此来自源头的许多单独的脉冲被迫协作，从而放大影响并确保接收设备的作用。通过这些工具，在许多情况下都获得了明显的优势；但很多时候，这种改进要么根本不适用，要么就算适用，收益也非常小。显然，当源头是一个产生连续压力或传递长时间脉冲的源头时，用这种方式放大效果是不切实际的，而另一方面，当源头是一个提供极端快速连续的短脉冲的源头时，由于辐射和接收电路中不可避免的摩擦损耗，以这种方式获得的优势也是微不足道的。这些损耗大大降低了协同脉冲的强度和数量，并且由于这些协同脉冲的每一个的初始强度必然是有限的，因此只有少量的能量可用于接收器的单次操作。由于这个量因此依赖于由一个单个脉冲传送到接收器的能量，显然有必要使用非常大，并且昂贵，因此令人讨厌的发射器，或者求助于同样令人讨厌的使用过于精密且太容易混乱的接收装置。此外，通过脉冲协作获得的能量是以极快振动的形式存在的，因此不适合普通接收器的操作，尤其是这种形式的能量对于应用此能量的设备的模式和时间有着严格的限制。本发明的目的是克服迄今为止在这种信号或情报传输系统中存在的这些和其它限制和缺点，本发明包括一种用于实现这些结果的新型装置。

The apparatus which is employed at the receiving-station, described in general terms, consists in the combination of a storage device included in a circuit connecting points at a distance from the source of the disturbances and between which a difference of potential is created by such disturbances, a receiving-circuit connected with the storage device, a receiver included in such receiving-circuit, and means for closing the receiving-circuit at any desired moment, and thereby causing the receiver to be operated by the energy with which the storage device has been charged.

概括地说，在接收站使用的设备包括：一个存储装置，它被包含在连接离扰动源一定距离的点的电路中，并且在这些点之间由这种扰动产生电位差；与该存储装置连接的一个接收电路；包含在这种接收电路中的一个接收器；以及用于在任何希望的时刻闭合接收电路的工具，从而使该接收器由存储装置中已存储的能量操作。

The best form of apparatus for carrying out my invention of which I am now aware and the manner of using the same will be understood from the following description and the accompanying drawings, in which—

从下面的描述和附图中，将会理解我现在所知道的用于实施我的发明的装置的最佳形式及其使用方式，其中—

Figure 1 is a diagrammatic illustration of such apparatus, and Fig. 2 a modified form or arrangement of the same.

图 1 是这种装置的示意图，图 2 是其改进的形式或布置。

At any two points in the transmitting medium between which there exists or may be obtained in any manner through the action of the disturbances or effects to be investigated or utilized a difference of electrical potential of any magnitude I arrange two plates or electrodes so that they may be oppositely

charged through the agency of such effects or disturbances, and I connect these electrodes to the terminals of a highly-insulated condenser, generally of considerable capacity. To the condenser-terminals I also connect the receiver to be operated in series with a device of suitable construction which performs the function of periodically discharging the condenser through the receiver at and during such intervals of time as may be best suitable for the purpose contemplated. This device may merely consist of two stationary electrodes separated by a feeble dielectric layer of minute thickness, or it may comprise terminals one or more of which are movable and actuated by any suitable force and are adapted to be brought into and out of contact with each other in any convenient manner. It will now be readily seen that if the disturbances, of whatever nature they may be, cause definite amounts of electricity of the same sign to be conveyed to each of the plates or electrodes above mentioned either continuously or at intervals of time which are sufficiently long the condenser will be charged to a certain potential and an adequate amount of energy being thus stored during the time determined by the device effecting the discharge of the condenser the receiver will be periodically operated by the electrical energy so accumulated; but very often the character of the impulses and the conditions of their use are such that without further provision not enough potential energy would be accumulated in the condenser to operate the receiving device. This is the case when, for example, each of the plates or terminals receives electricity of rapidly-changing sign or even when each receives electricity of the same sign, but only during periods of which are short as compared with the intervals separating them. In such instances I resort to the use of a special device which I insert in the circuit between the plates and the condenser for the purpose of conveying to each of the terminals of the latter electrical charges of the proper quality and order of succession to enable the required amount of potential energy to be stored in the condenser.

在传输媒介中的任意两点之间,存在或可以以任何方式通过要研究或利用的扰动或效应的作用获得任意大小的电势差。我布置两个板或电极,以便它们可以通过这种效应或扰动的作用带相反的电荷,我将这些电极连接到一个被高度绝缘的电容器的终端,该电容器通常具有相当大的电容量。我还将接收器连接到电容器的两个终端上,该接收器与一个适当构造的装置串联操作,该装置的功能是通过接收器以最适合预期目的的时间间隔或在最适合预期目的的时间间隔期间周期性地使电容器放电。该装置可以仅由被微小厚度的弱介电层隔开的两个静态电极组成,或者它可以包括终端,其中一个或多个终端是可移动的,并且由任何合适的力驱动,并且适于以任何方便的方式彼此接触和脱离接触。现在可以很容易地看出,如果不管是什么性质的扰动,它们可以导致在连续的或以足够长的时间间隔由相同符号的确定量的电输送到上述的每个板或电极,电容器将被充电到某一电势,并且在由实现电容器放电的装置所确定的时间期间,存储了足够量的能量,接收器将由这样积累的电能周期性地操作;但是通常脉冲的特性和它们的使用条件是这样的,如果没有进一步的准备,在电容器中不会积累足够的势能来操作接收装置。例如,当每个板或终端接收快速变化符号的电力时,或者甚至当每个接收到相同符号的电时,都是这种情况,但是仅在与分隔它们的间隔相比较短的时间段内。在这种情况下,我求助于使用一种特殊的装置,我插入的在板和电容器之间的电路,目的是将适当品质和序列顺序的电荷传输到后者的每个终端,以使所需数量的势能存储在电容器中。

There are a number of well-known devices, either without any moving parts or terminals or with elements reciprocated or rotated by the application of a suitable force, which offer a more ready passage to impulses of one sign or direction than to those of the other or permit only impulses of one kind or order of succession to traverse a path, and any of these or similar devices capable of fulfilling the requirements may be used in carrying my invention into practice. One such device of familiar

construction which will serve to convey a clear understanding of this part of my invention and enable a person skilled in the art to apply the same is illustrated in the annexed drawings. It consists of a cylinder A, of insulating material, which is moved at a uniform rate of speed by clockwork or other suitable motive power and is provided with two metal rings B B', upon which bear brushes a and a', which are connected, respectively, in the manner shown to the terminal plates P and P', above referred to. From the rings B B' extend narrow metallic segments s and s', which by the rotation of the cylinder A are brought alternately into contact with double brushes b and b', carried by and in contact with conducting-holders h and h', which are adjustable longitudinally in the metallic supports D and D', as shown. The latter are connected to the terminals T and T' of a condenser C, and it should be understood that they are capable of angular displacement as ordinary brush-supports. The object of using two brushes, as b and b', in each of the holders h and h' is to vary at will the duration of the electric contact of the plates P and P' with the terminals T and T', to which is connected a receiving-circuit, including a receiver R and a device d of the kind above referred to, which performs the duty of closing the receiving-circuit at predetermined intervals of time and discharging the stored energy through the receiver. In the present case this device consists of a cylinder d, made partly of conducting and partly of insulating material e and e', respectively, which is rotated at the desired rate of speed by any suitable means. The conducting part e is in good electrical connection with the shaft S and is provided with tapering segments f f, upon which slides a brush k, supported on a conducting-rod l, capable of longitudinal adjustment in a metallic support m. Another brush n is arranged to bear upon the shaft S, and it will be seen that whenever one of the segments f comes in contact with the brush k the circuit including the receiver R is completed and the condenser discharged through the same. By an adjustment of the speed of rotation of the cylinder d and a displacement of the brush k along the cylinder the circuit may be made to open and close in as rapid succession and remain open or closed during such intervals of time as may be desired. The plates P and P' through which the electrifications are conveyed to the brushes a and a' may be at a considerable distance from each other and both in the ground or both in the air or one in the ground and the other in the air, preferably at some height, or they may be connected to conductors extending to some distance or to the terminals of any kind of apparatus supplying electrical energy which is obtained from the energy of the impulses or disturbances transmitted from a distance through the natural media.

有许多众所周知的装置，或者没有任何移动部件或终端，或者具有通过施加适当的力能往复运动或旋转的组件，这些装置为一种符号或一种方向的脉冲提供比另一种符号或方向的脉冲更容易的通道，或者仅允许一种类型或一种序列顺序的脉冲通过路径，并且能够满足要求的这些装置或类似装置中的任何一个都可以用于实施我的发明。在附图中展示了一种类似结构的装置，该装置将用于传达对本发明的这一部分的清楚理解，并使本领域技术人员能够应用该装置。它由绝缘材料制成的圆筒 A 组成，该圆筒由发条装置或其它合适的动力以一致的速度移动，并设有两个金属环 B B'，在金属环 B B'上装有电刷 a 和 a'，电刷 a 和 a'分别以上述所示的方式连接到终端板 P 和 P'上。从环 B B'延伸出窄的金属段 s 和 s'，通过圆筒 A 的旋转，金属段交替地与双电刷 b 和 b'接触，双电刷 b 和 b'由导电支架 h 和 h'承载并与之接触，导电支架 h 和 h'在金属支架 D 和 D'中可纵向调节，如图所示。后者连接到电容器 C 的终端 T 和 T'，应该理解，终端 T 和 T'能够像普通电刷支架一样进行角位移。在每个支架 h 和 h'中使用如 b 和 b'这样的两个电刷的目的是随意改变板 P 和 P'与终端 T 和 T'的电接触持续时间，终端 T 和 T'连接有接收电路，该接收电路包括一个接收器 R 和上述类型的一个装置 d，该装置 d 以预定的时间间隔闭合接收电路并通过接收器释放存储的能量。在这种情况下，该装置包括一个圆筒 d，一部分由导电材料 e 制成和一部分由绝缘材料 e'制成，该圆筒通过任何

合适的工具以所需的速度旋转。导电部分 c 与轴 S 具有良好的电连接，并配有锥形分段 ff，在锥形分段 ff 上滑动一个电刷 k，电刷 k 由一个导电杆 l 支撑，导电杆 l 能够在金属支架 m 中纵向调节另一个电刷 n 被布置成倚靠在轴 S 上，可以看出，每当一个分段 f 与电刷 k 接触时，包含接收器 R 在内的电路接通，电容器通过该电路放电。通过调节圆筒 d 的转速和电刷 k 沿滚筒的位移，可以使该电路快速连续地断开和闭合，并在所需的时间间隔期间保持断开和闭合。通过板 P 和 P' 将电气化传送到电刷 a 和 a'，板 P 和 P' 可以彼此相距相当远，并且都在地面下或都在空中，或者一个在地面下而另一个在空中，最好是在某个高度上，或者它们可以连接到延伸到某个距离的导体上，或者它们可以连接到已经延伸到某个距离的导体上，或者连接到任何一种提供电能的装置的不同终端上，该电能是从远处通过自然媒介传输的脉冲或扰动的能量中获得的。

In illustration of the operation of the devices described let it be assumed that alternating electrical impulses from a distant generator, as G, are transmitted through the earth and that it is desired to utilize these impulses in accordance with my method. This may be the case, for example, when such a generator is used for purposes of signaling in one of the ways before enumerated, as by having its terminals connected at two points of the earth distant from each other. In this case the plates P and P' are first connected to two properly-selected points of the earth, the speed of rotation of the cylinder A is varied until it is made to turn in synchronism with the alternate impulses of the generator, and, finally, the position of the brushes b and b' is adjusted by angular displacement, as usual, or in other ways, so that they are in contact with the segments s and s' during the periods when the impulses are at or near the maximum of their intensity. Only ordinary electrical skill and knowledge are required to make these adjustments, and a number of devices for effecting synchronous movement being well known and it being the chief object of my present application to set forth a novel apparatus embodying a general principle a detailed description of such devices is not considered necessary. I may state, however, that for practical purposes in the present case it is only necessary to shift the brushes back and forth until the maximum effect is secured. The above requirements being fulfilled, electrical charges of the same sign will be conveyed to each of the condenser-terminals as the cylinder A is rotated, and with each fresh impulse the condenser will be charged to a higher potential. The speed of rotation of the cylinder d being adjustable at will, the energy of any number of separate impulses may thus be accumulated in potential form and discharged through the receiver R upon the brush k coming in contact with one of the segments f. It will be of course understood that the capacity of the condenser should be such as to allow the storing of a much greater amount of energy than is required for the ordinary operation of the receiver. Since by this method a relatively great amount of energy and in a suitable form may be made available for the operation of a receiver, the latter need not be very sensitive; but of course then the impulses are very feeble, as when coming from a great distance or when it is desired to operate a receiver very rapidly, then any of the well-known devices capable of responding to very feeble influences may be used in this connection.

在说明所述设备的操作时，假设来自远处发电机（如 G）的交流电脉冲，通过大地传输，并且希望根据我的方法利用这些脉冲。例如，当这种发电机用于以前面列举的方式之一发送信号时，例如通过将其终端连接到地球上彼此远离的两点，就可能是这种情况。在这种情况下，板 P 和 P' 首先连接到地球的两个适当选择的点，圆筒 A 的转速是变化的，直到它与发电机的交变脉冲同步，最后，刷 b 和 b' 的位置由角位移来调节，如通常那样，或以其它方式，这样，在脉冲强度达到或接近最大值时，电刷 b 和 b' 与分段 s 和 s' 接触。进行这些调整只需要普通的电气技能和知识，并且许多用于实现同步运动的装置是众所周知的，并且我的本申请

的主要目的是提出一种体现一般原理的新颖设备，对这些装置的详细描述被认为是不必要的。然而，我可以声明，实际上在这种情况下，只需要向后或向前移动电刷，直到获得最大效果。满足上述要求，当圆柱体 A 旋转时，相同符号的电荷将被传送到每个电容器的终端上，并且随着每个新的脉冲，电容器将被充电到更高的电势。圆柱体 d 的旋转速度可以随意调节，因此任何数量的独立脉冲的能量可以以电势的形式积累，并在电刷 k 与其中一个分段 f 接触时通过接收器 R 放电。当然可以理解，电容器的容量应该允许储存比接收器正常工作所需的能量大得多的能量。因为通过这种方法，相对大量的能量以一个适当的形式可以用于一个接收器的操作，所以后者不需要非常敏感；但是当然，当脉冲非常微弱时，例如当来自很远的距离时，或者当希望非常快速地操作接收器时，则可以在这种连接中使用能够响应非常微弱的影响的任何众所周知的设备。

If instead of the alternating impulses short impulses of the same direction are conveyed to the plates P and P', the apparatus described may still readily be used, and for this purpose it is merely necessary to shift the brushes b and b' into the position indicated by the dotted lines, while maintaining the same conditions in regard to synchronism as before, so that the succeeding impulses will be permitted to pass into the condenser, but prevented from returning to the ground or transmitting medium during the intervals between them, owing to the interruption during such intervals of the connections leading from the condenser-terminals to the plates.

如果不是交流脉冲，而是相同方向的短脉冲被传送到板 P 和 P'，所述装置仍然可以容易地使用，为此目的，只需要将电刷 b 和 b' 移动到虚线所示的位置，同时保持与前面相同的同步状态，以便允许随后的脉冲进入电容器，但是在它们之间的时间间隔期间，由于从电容器终端到板的连接在这种时间间隔期间的中断，防止脉冲返回到接地或传输媒介。

Another way of using the apparatus with impulses of the same direction is to take off one pair of brushes, as b, disconnect the plate P from brush a and join it directly to the terminal T of the condenser, and to connect brush a with brush a'. When thus modified, the apparatus appears as shown in Fig. 2. Operated in this manner and assuming the speed of rotation of cylinder A to be the same, the apparatus will now be evidently adapted for a number of impulses per unit of time twice as great as in the preceding case. In all cases it is evidently important to adjust the duration of contact of segments s and s' with brushes b b' in the manner indicated.

使用具有相同方向脉冲的装置的另一种方法是取下一对电刷，如 b，将板 P 从电刷 a 上断开，并将其直接连接到电容器的终端 T 上，并将电刷 a 与电刷 a' 连接起来。如此修改的设备将如图 2 所示。以这种方式操作并假设圆筒 A 的转速相同，该装置现在将明显地适用于每单位时间的脉冲数量是前一种情况的单位时间内的两倍的情况。在所有情况下，以指定的方式调节分段 s 和 s' 与电刷 b 和 b' 的接触时间显然是很重要的。

When the apparatus I have described is used in connection with the transmission of signals or intelligence, it will of course be understood that the transmitter is operated in such a way as to produce disturbances or effects which are varied or intermitted in some arbitrary manner—for example, to produce longer and shorter successions of impulses, corresponding to the dashes and dots of the Morse alphabet—and the receiving device will respond to and indicate these variations or intermittence, since the storage device will be charged and discharged a number of times corresponding to the duration of the successions of impulses received.

当我所描述的装置与信号或情报的传输结合使用时，当然可以理解，发射机以这样一种方式工作，来产生以某种任意方式变化或间断的扰动或影响，例如，产生对应于莫尔斯字母表的破折号和点的较长或较短的脉冲序列，并且接收设备将响应并指示这些变化或间断，因为储能设备将被充电和放电多次对应于所接收的脉冲序列的持续时间。

Obviously the special appliances used in carrying out my invention may be varied in many ways without departing from the spirit of the same.

显然，在不脱离本发明的精神的情况下，用于实现我的发明的特殊装置可以以多种方式变化。

It is to be observed that it is the function of the cylinder A, with its brushes and connections, to render the electrical impulses coming from the plates P and P' suitable for charging the condenser (assuming them to be unsuitable for this purpose in the form in which they are received) by rectifying them when they are originally alternating in direction or by selecting such parts of them as are suitable when all are not, and any other device performing this function will obviously answer the purpose. It is also evident that a device such as I have already referred to which offers a more ready passage to impulses of one sign or permits only impulses of the same sign to pass may also be used to perform this selective function in many cases when alternating impulses are received. When the impulses are long and all of the same direction, and even when they are alternating but sufficiently long in duration and sustained in electromotive force, the brushes b and b' may be adjusted so as to bear on the parts B B' of the cylinder A, or the cylinder and its brushes may be omitted and the terminals of the condenser connected directly to the plates P and P'.

可以观察到，具有电刷和连接的圆筒 A 的功能是使来自板 P 和 P' 的电脉冲适合于给电容器充电（假设它们是以不适合此目的方式被接收），当它们最初方向交替时通过整流它们，或者当它们在所有方向都不交替时通过选择它们中适合的部分，并且执行该功能的任何其它装置将显然满足该目的。同样明显的是，在许多情况下，当接收到交替的脉冲时，诸如我已经提到的为一个符号的脉冲提供更容易的通道或者只允许相同符号的脉冲通过的装置也可以用于执行这种选择功能。当脉冲很长并且都是同一个方向时，甚至当它们是交变的，但是持续时间足够长并且维持电动势时，电刷 B 和 B' 可以被调整以便倚靠在圆筒 A 的分段 B B' 上，或者圆筒及其电刷可以被省略，电容器的终端直接连接到板 P 和 P' 上。

It will be seen that by the use of my invention results hitherto unattainable in utilizing disturbances or effects transmitted through natural media may be readily attained, since however great the distance of such transmission and however feeble or attenuated the impulses received enough energy may be accumulated from them by storing up the energy of succeeding impulses for a sufficient interval of time to render the sudden liberation of it highly effective in operating a receiver. In this way receivers of a variety of forms may be made to respond effectively to impulses too feeble to be detected or to be made to produce any sensible effect in any other way of which I am aware—a result of great value in scientific research as well as in various applications to practical use.

可以看出，通过使用我的发明，可以容易地获得迄今为止在利用通过自然媒介传输的扰动或效应方面无法获得的结果，因为无论这种传输的距离有多远，无论接收到的脉冲有多么微弱或多么减弱，足够的能量可以通过存储随后的脉冲的能量由这些脉冲积累足够长的一段时间间隔，以使能量的突然释放在操作接收器时非常有效。通过这种方式，可以使各种形式的接

收器有效地响应太微弱而无法检测到的脉冲,或者以我所知道的任何其他方式产生任何可感知的效果,据我所知——这一结果在科学研究和各种实际应用中具有巨大的价值。

What I claim as my invention, and desire to secure by Letters Patent, is—

我主张的是我的发明,并希望通过专利证书来保护的是—

1. In an apparatus for utilizing electrical effects or disturbances transmitted through the natural media, the combination with a source of such effects or disturbances of a charging-circuit adapted to be energized by the action of such effects or disturbances, a storage device included in the charging-circuit and adapted to be charged thereby, a receiver, and means for causing the receiver to be operated by the energy accumulated in the storage device at arbitrary intervals of time, substantially as described.

1、在一种利用通过自然媒介传输的电效应或扰动的装置中的组合,它包括一个充电电路的这种影响或扰动的来源,该充电电路适于通过这种影响或扰动的作用而被激励;还有被包含在充电电路中并适于由此被充电的存储设备;还有一个接收器和用于使接收器以任意时间间隔由存储设备中积累的能量操作的工具,基本上如所述。

2. In an apparatus for utilizing electrical effects or disturbances transmitted through the natural media, the combination with a source of such effects or disturbances of a charging-circuit adapted to be energized by the action of such effects or disturbances, a storage device included in the charging-circuit and adapted to be charged thereby, means for commutating, directing or selecting the current impulses in the charging-circuit, a receiving-circuit, and means for discharging the storage device through the receiving-circuit, substantially as described.

2、在一种利用通过自然媒介传输的电效应或扰动的装置中的组合,它包括一个充电电路的这种影响或扰动的来源,该充电电路适于通过这种影响或扰动的作用而被激励;还有被包含在充电电路中并适于由此被充电的存储设备;还有用于整流、引导或选择充电电路中的电流脉冲的工具;还有一个接收电路,以及用于通过该接收电路对该存储设备放电的工具,基本上如所述。

3. In an apparatus for utilizing electrical effects or disturbances transmitted through the natural media, the combination with a source of such effects or disturbances of a charging-circuit adapted to be energized by the action of such effects or disturbances, a condenser included in the charging-circuit and adapted to be charged thereby, means for commutating, directing or selecting the current impulses in the charging-circuit, a receiving-circuit, and means for discharging the condenser through the receiving-circuit, substantially as described.

3、在一种利用通过自然媒介传输的电效应或扰动的装置中的组合,它包括一个充电电路的这种影响或扰动的来源,该充电电路适于通过这种影响或扰动的作用而被激励;还有被包含在充电电路中并适于由此被充电的电容器;还有用于整流、引导或选择充电电路中的电流脉冲的工具;还有一个接收电路;以及用于通过该接收电路对该存储设备放电的工具,基本上如所述。

4. In an apparatus for utilizing electrical effects or disturbances transmitted through the natural media,

the combination with a source of such effects or disturbances of a charging-circuit adapted to be energized by the action of such effects or disturbances, a storage device included in the charging-circuit and adapted to be charged thereby, means for commutating, directing or selecting the current impulses in the charging-circuit so as to render them suitable for charging the storage device, a receiving-circuit, and means for discharging the storage device through the receiving-circuit, substantially as described.

4、在一种利用通过自然媒介传输的电效应或扰动的装置中的组合，它包括一个充电电路的这种影响或扰动的来源，该充电电路适于通过这种影响或扰动的作用而被激励；还有被包含在充电电路中并适于由此被充电的存储装置；还有用于整流、引导或选择充电电路中的电流脉冲以使它们适于对该存储装置充电的工具；还有一个接收电路，以及用于通过该接收电路对该存储装置放电的工具，基本上如所述。

5. In an apparatus for utilizing electrical effects or disturbances transmitted through the natural media, the combination with a source of such effects or disturbances of a charging-circuit adapted to be energized by the action of such effects or disturbances, a condenser included in the charging-circuit and adapted to be charged thereby, means for commutating, directing or selecting the current impulses in the charging-circuit so as to render them suitable for charging the condenser, a receiving-circuit, and means for discharging the condenser through the receiving-circuit, substantially as described.

5、在一种利用通过自然媒介传输的电效应或扰动的装置中的组合，它包括一个充电电路的这种影响或扰动的来源，该充电电路适于通过这种影响或扰动的作用而被激励；还有被包含在充电电路中并适于由此被充电的一个电容器；还有用于整流、引导或选择充电电路中的电流脉冲以使它们适于对该电容器充电的工具；还有一个接收电路，以及用于通过该接收电路对该电容器放电的工具，基本上如所述。

6. In an apparatus for utilizing electrical effects or disturbances transmitted through the natural media, the combination with a source of such effects or disturbances of a charging-circuit adapted to be energized by the action of such effects or disturbances, a storage device included in the charging-circuit and adapted to be charged thereby, means for commutating, directing or selecting the current impulses in the charging-circuit so as to render them suitable for charging the storage device, a receiving-circuit, and means for discharging the storage device through the receiving-circuit at arbitrary intervals of time, substantially as described.

6、在一种利用通过自然媒介传输的电效应或扰动的装置中的组合，它包括一个充电电路的这种影响或扰动的来源，该充电电路适于通过这种影响或扰动的作用而被激励；还有被包含在充电电路中并适于由此被激励的一个存储设备；还有用于整流、引导或选择充电电路中的电流脉冲以使它们适合于对该存储设备充电的工具；还有一个接收电路，以及用于以任意时间间隔通过该接收电路对该存储设备放电的工具，基本上如所述。

7. In an apparatus for utilizing electrical effects or disturbances transmitted to a distant receiving-station, the combination with a source of such effects or disturbances of a circuit distant from the source and adapted to have current impulses set up in it by the action of the effects or disturbances, a storage device, means for commutating, directing or selecting the impulses and connecting the circuit with the storage device at succeeding intervals of time synchronizing with the impulses, a receiving-circuit, and means for periodically discharging the storage device through the receiving-circuit, substantially as

described.

7、在一种利用传输到远处接收站的电效应或扰动的装置中的组合，它包括一个电路的这种效应或扰动的一个来源，该电路远离该来源，并通过效应或扰动的作用使电流脉冲在该电路中产生；还包括一个存储装置；还包括用于整流、引导或选择脉冲并以与脉冲同步的连续时间间隔将电路与该存储装置连接的工具；还包括一个接收电路，以及用于通过该接收电路周期性地对存储装置放电的工具，基本上如所述。

8. In an apparatus for utilizing electrical effects or disturbances transmitted to a distant receiving-station, the combination with a source of such effects or disturbances of a circuit distant from the source and adapted to have current impulses set up in it by the action of the effects or disturbances, a condenser, means for commutating, directing or selecting the impulses and connecting the circuit with the condenser at succeeding intervals of time synchronizing with the impulses, a receiving-circuit, and means for periodically discharging the condenser through the receiving-circuit, substantially as described.

8、在一种利用传输到远处接收站的电效应或扰动的装置中的组合，它包括一个电路的这种效应或扰动的一个来源，该电路远离该来源，并通过效应或扰动的作用使电流脉冲在该电路中产生；还包括一个电容器；还有用于整流、引导或选择脉冲并在以脉冲同步的连续时间间隔将电路与电容器连接的工具；还包括一个接收电路，以及用于通过该接收电路周期性地对该电容器放电的工具，基本上如所述。

9. In an apparatus for utilizing electrical effects or disturbances transmitted through the natural media, the combination with a source of such effects or disturbances of a circuit connecting points at a distance from the source between which a difference of potential is created by such effects or disturbances, a storage device included in such circuit and adapted to be charged with the energy supplied by the same, a receiving-circuit connected with the storage device, a receiver included in such receiving-circuit, and means for closing the receiving-circuit and thereby causing the receiver to be operated by the energy accumulated in the storage device, substantially as described.

9、在一种用于利用通过自然媒介传输的电效应或扰动的装置中的组合，它包括一个电路的这种效应或扰动的一个来源，距离该来源有一定距离的连接点之间的电位差是由这种效应或扰动产生的；还包括在这种电路中并适于由这种电路提供的能量进行充电的一个存储设备；还有与存储设备相连接的一个接收电路；还包括在该接收电路中的一个接收器，以及用于闭合接收电路并由此使得接收器通过存储装置中积累的能量进行操作的工具，基本上如所述。

10. In an apparatus for utilizing electrical effects or disturbances transmitted through the natural media, the combination with a source of such effects or disturbances of a circuit at a distance from the source which is energized by such effects or disturbances, a storage device adapted to be charged with the energy supplied by such circuit, means for connecting the storage device with the said circuit for periods of time predetermined as to succession and duration, a receiving-circuit connected with the storage device, a receiver included in such receiving-circuit, and means for closing the receiving-circuit and thereby causing the receiver to be operated by the energy accumulated in the storage device, substantially as described.

10、在一种利用传输到远处接收站的电效应或扰动的装置中的组合，它包括一个电路的这种效应或扰动的来源，该电路远离该来源并由这种效应或扰动所激励；还包括一个适于用这种电路提供的能量充电的存储装置；还包括用于在预定的连续和持续时间内将该存储装置与所述电路相连接的工具；还包括与该存储装置连接的一个接收电路；一个被包含在这种接收电路中的接收器；以及用于闭合接收电路从而使接收器由该存储装置中积累的能量操作的工具，基本上如所述。

11. In an apparatus for utilizing electrical effects or disturbances transmitted through the natural media, the combination of a circuit connecting points at a distance from the source between which a difference of potential is created by such effects or disturbances, a storage device included in such circuit and adapted to be charged with the energy supplied by the same, a receiving-circuit, a receiver included in such circuit, and means for connecting the receiving-circuit with the storage device for periods of time predetermined as to succession and duration and thereby causing the receiver to be operated by the energy accumulated in the storage device, substantially as described.

11、在一种利用通过自然媒介传输的电效应或扰动的装置中的组合，它包括一个电路，它连接距离来源一定距离的不同点，这些点之间的电位差是由这种效应或扰动产生的；还包括一个被包含在这样的电路中的一个存储装置并适合于由该电路提供的能量充电；还有一个接收电路和一个被包含在这样的电路中的一个接收器；以及用于将该接收电路与该存储设备连接一段时间的工​​具，该段时间是预先确定的连续时间和持续时间，从而使得接收器由存储设备中积累的能量进行操作，基本上如所述。

12. In an apparatus for utilizing electrical effects or disturbances transmitted through the natural media, the combination of a circuit connecting points at a distance from the source between which a difference of potential is created by such effects or disturbances, a storage device adapted to be charged with the energy supplied by such circuit for succeeding and predetermined periods of time, a receiving-circuit, a receiver included in the receiving-circuit, and means for connecting the receiving-circuit with the storage device for periods of time predetermined as to succession and duration and thereby causing the receiver to be operated by the energy accumulated in the storage device, substantially as described.

12、在一种利用通过自然媒介传输的电效应或扰动的装置中的组合，它包括一个电路，它连接距离来源一定距离的不同点，这些点之间的电位差是由这种效应或扰动产生的；还包括一个适于在随后的预定时间段内用这种电路提供的能量充电的存储装置；还包括一个接收电路和一个被包含在这样的电路中的一个接收器；以及用于将该接收电路与该存储设备连接一段时间的工​​具，该段时间是预先确定的连续时间和持续时间，从而使得接收器由存储设备中积累的能量进行操作，基本上如所述。

13. In an apparatus for utilizing electrical effects or disturbances transmitted through the natural media, the combination of a circuit connecting points at a distance from the source, between which a difference of potential is created by such effects or disturbances, a condenser included in such circuit and adapted to be charged by the current in the same, a receiving-circuit connected with the condenser, a receiver included in such receiving-circuit, and a device adapted to close the receiving-circuit at arbitrary intervals of time and thereby cause the receiver to be operated by the electrical energy accumulated in the condenser, substantially as described.

13、在一种利用通过自然媒介传输的电效应或扰动的装置中的组合，它包括一个电路，它连接距离来源一定距离的不同点，这些点之间的电位差是由这种效应或扰动产生的；还包括在这种电路中的一个电容器，该电容器适于由该电路中的电流充电；还包括与该电容器连接的一个接收电路；还有被包含在这种接收电路中的一个接收器；以及适于以任意时间间隔闭合接收电路并由此使得接收器由电容器中积累的电能进行操作的设备，基本如上所述。

14. In an apparatus for utilizing electrical effects or disturbances transmitted through the natural media, the combination of a charging-circuit distant from the source and energized by the effects or disturbances, a storage device included in the charging-circuit, means included in the charging-circuit and acting in synchronism with the impulses therein for commutating, directing or selecting the impulses, a receiving-circuit and means for periodically discharging the storage device through the receiving-circuit, substantially as described.

14、在一种利用通过自然媒介传输的电效应或扰动的装置中的组合，它包括一个远离电源并由电效应或扰动所激励的充电电路；一个被包含在充电电路中的存储装置；被包含在该充电电路中并与其中的脉冲同步作用以整流、引导或选择脉冲的工具；一个接收电路和通过该接收电路周期性地对存储装置放电的工具，基本上如所述。

15. In an apparatus for utilizing electrical effects or disturbances transmitted through the natural media, the combination of a charging-circuit distant from the source and energized by the effects or disturbances, a condenser included in the charging-circuit, means included in the charging-circuit and acting in synchronism with the impulses therein for commutating, directing or selecting the impulses, a receiving-circuit and means for periodically discharging the condenser through the receiving-circuit, substantially as described.

15、在一种利用通过自然介质传输的电效应或扰动的装置中的组合，它包括一个远离电源并由电效应或扰动所激励的充电电路；一个被包含在充电电路中的电容器；被包含在该充电电路中并与其中的脉冲同步作用以整流、引导或选择脉冲的工具；一个接收电路和通过该接收电路周期性地使电容器放电的工具，基本上如所述。

16. In an apparatus for transmitting signals or intelligence through the natural media from a sending-station to a distant point, the combination of a generator or transmitter adapted to produce arbitrarily varied or intermitted electrical disturbances or effects in the natural media, a charging-circuit at the distant point adapted to receive corresponding electrical impulses or effects from the disturbances or effects so produced, a storage device included in the charging-circuit, means included in the charging-circuit and acting in synchronism with the impulses therein for commutating, directing or selecting the impulses so as to render them suitable for charging the storage device, a receiving-circuit and means for periodically discharging the storage device through the receiving-circuit, substantially as described.

16、在一种通过自然介质从发送站向远处发送信号或信息的设备中的组合，它包括一个发生器或发送器，适合于在自然介质中产生任意变化或间歇的电扰动或效应；一个在远处的充电电路适合于从如此产生的扰动或效应中接收相应的电脉冲或效应；一个被包含在充电电路中的存储装置；被包含在充电电路中并与其中的脉冲同步作用的工具，用于换向、引导或选择脉冲以使它们适合于对存储装置进行充电；一个接收电路和用于通过该接收电路周期性地对存储装置放电的工具，基本上如所述。

17. In an apparatus for transmitting signals or intelligence through the natural media from a sending-station to a distant point, the combination of a generator or transmitter adapted to produce arbitrarily varied or intermitted electrical disturbances or effects in the natural media, a charging-circuit at the distant point adapted to receive corresponding electrical impulses or effects from the disturbances or effects so produced, a condenser included in the charging-circuit, means included in the charging-circuit and acting in synchronism with the impulses therein for commutating, directing or selecting the impulses so as to render them suitable for charging the condenser, a receiving-circuit and means for periodically discharging the condenser through the receiving-circuit, substantially as described.

17、在一种通过自然介质从发送站向远处发送信号或信息的设备中的组合，它包括一个发生器或发送器，适合于在自然介质中产生任意变化或间歇的电扰动或效应；一个在远处的充电电路适合于从如此产生的扰动或效应中接收相应的电脉冲或效应；一个被包含在充电电路中的电容器；被包含在充电电路中并与其中的脉冲同步作用的工具，用于换向、引导或选择脉冲以使它们适合于对电容器进行充电；一个接收电路和用于通过接收电路周期性地对电容器放电的工具，基本上如所述。

18. In an apparatus for transmitting signals or intelligence through the natural media from a sending-station to a distant point, the combination of a generator or transmitter adapted to produce arbitrarily varied or intermitted electrical disturbances or effects in the natural media, a circuit at the distant point adapted to receive corresponding electrical impulses or disturbances from the disturbances or effects so transmitted, a storage device included in such circuit and adapted to be charged thereby, a receiving-circuit connected with the storage device, a receiver included in the receiving-circuit and a device for closing the receiving-circuit at arbitrary intervals of time and thereby causing the receiver to be operated by the energy accumulated in the storage device, substantially as described.

18、在一种通过自然介质从发送站向远处发送信号或情报的设备中的组合，它包括一个发生器或发送器，适合于在自然介质中产生任意变化或间歇的电扰动或效应；一个在远处的电路适合于从如此发送的扰动或效应中接收相应的电脉冲或扰动；一个被包含在这种电路中并适合于由此充电的存储装置；一个与存储装置连接的接收电路；一个被包含在接收电路中的接收器；以及用于以任意时间间隔闭合接收电路从而使得接收器由存储装置中积累的能量进行操作的设备，基本上如所述。

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N. TESLA.

APPARATUS FOR UTILIZING EFFECTS TRANSMITTED FROM A DISTANCE TO A
RECEIVING DEVICE THROUGH NATURAL MEDIA.

(Application filed Sept. 8, 1899. Renewed May 29, 1901.)

(No Model.)

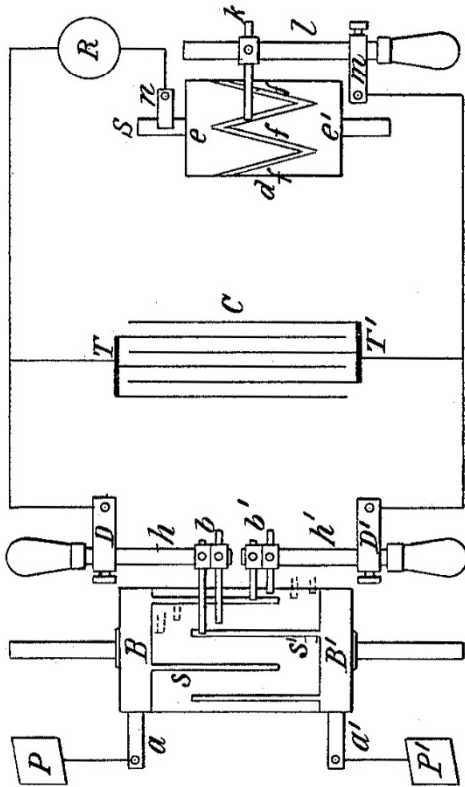


Fig. 1

(G)

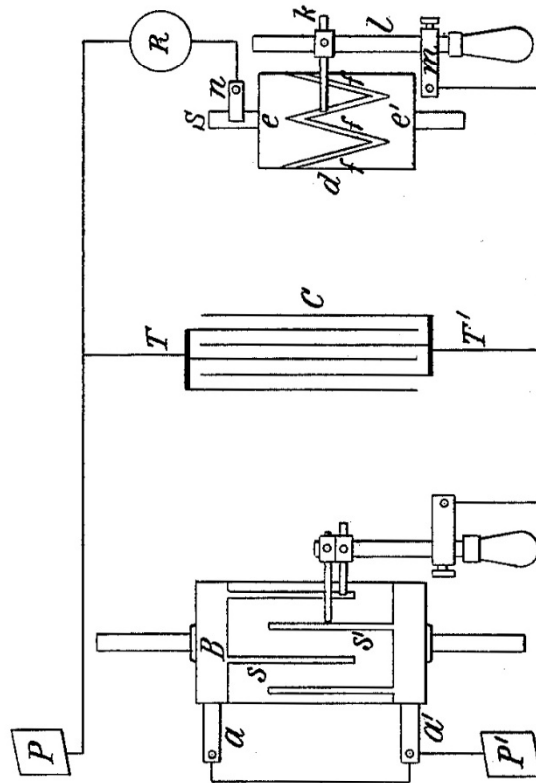


Fig. 2

(G)

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Att'ys

APPARATUS FOR UTILIZING EFFECTS TRANSMITTED THROUGH NATURAL MEDIA.

利用通过自然媒介传播的效果的装置

NIKOLA TESLA, OF NEW YORK, N. Y.

纽约州纽约市的尼古拉·特斯拉

SPECIFICATION forming part of Letters Patent No. 685,956, dated November 5, 1901.

Original application filed August 1, 1899, Serial No. 725,749. Divided and this application filed November 2, 1899. Renewed May 29, 1901. Serial No. 62,318. (No model.)

该说明书形成了颁发于 1901 年 11 月 5 日的专利证书 685,956 的一部分。

原始申请于 1899 年 8 月 1 日提交，序列号为 725,749。此申请于 1899 年 11 月 2 日被分立。

1901 年 5 月 29 日更新。序列号 62,318。(无模型。)

To all whom it may concern:

致所有相关人士:

Be it known that I, NIKOLA TESLA, a citizen of the United States, residing at New York city, in the county and State of New York, have invented a certain new and useful Improvement in Apparatus for Utilizing Effects Transmitted from a Distance to a Receiving Device Through the Natural Media, of which the following is a specification, reference being had to the accompanying drawings, which form a part of the same.

众所周知，我，尼古拉·特斯拉，美国公民，居住在纽约州纽约郡纽约市，已经发明了某种新的和有用的改进装置，用于利用通过自然媒介从远处传输到接收设备的效果，以下是该发明一个说明书，必须参考随附的图纸，它已形成该说明书的一部分。

The subject of my present invention is an improvement in the art of utilizing effects transmitted from a distance to a receiving device through the natural media; and it consists in the novel apparatus hereinafter described.

本发明的主题是对利用通过自然媒介从远处传输到接收设备的效果的技术的改进；并且它存在于下文描述的新颖设备中。

This application is a division of one filed by me August 1, 1899, Serial No. 725,749, and based upon and claiming the method herein described and which may be practiced by the use of apparatus forming the subject of this application.

本申请是本人于 1899 年 8 月 1 日提交的序列号为 725,749 的申请的一个分案，基于并主张保护这里描述的方法，并且该方法可以通过使用形成本申请主题的装置来实施。

My invention is particularly useful in connection with methods and apparatus for operating distant receiving devices by means of electrical disturbances produced by proper transmitters and conveyed to such receiving devices through the natural media; but it obviously has a wider range of applicability and may be employed, for example, in the investigation or utilization of terrestrial, solar, or other disturbances produced by natural causes.

我的发明特别适用于由适当的发射器产生并通过自然媒介传送到这些接收设备的电扰动来操作远距离接收设备的方法和装置；但它显然具有更广泛的适用性，例如可用于研究或利用由地球、太阳或其他由自然原因产生的扰动。

Several ways or methods of transmitting electrical disturbances through the natural media and utilizing them to operate distant receivers are now known and have been applied with more or less success for accomplishing a variety of useful results. One of these ways consists in producing by a suitable apparatus rays or radiations—that is, disturbances—which are propagated in straight lines through space, directing them upon a receiving or recording apparatus at a distance, and thereby bringing the latter into action. This method is the oldest and best known and has been brought particularly into prominence in recent years through the investigations of Heinrich Hertz. Another method consists in passing a current through a circuit, preferably one enclosing a very large area, inducing thereby in a similar circuit situated at a distance another current and affecting by the same in any convenient way a receiving device. Still another way, which has also been known for many years, is to pass in any suitable manner a current through a portion of the ground, as by connecting to two points of the same, preferably at a considerable distance from each other, the two terminals of a generator and to energize by a part of the current diffused through the earth a distant circuit, which is similarly arranged and grounded at two points widely apart and which is made to act upon a sensitive receiver. These various methods have their limitations, one especially, which is common to all, being that the receiving circuit or instrument must be maintained in a definite position with respect to the transmitting apparatus, which often imposes great disadvantages upon the use of the apparatus.

通过自然媒介传输电扰动并利用它们来操作远程接收器的几种方式或方法现在是已知的，并且已经或多或少成功地应用于实现各种有用的结果。其中一种方法是通过一个合适的装置产生射线或辐射——即扰动——这些射线或辐射在空间中直线传播，将它们导向远处的接收或记录装置，从而使后者起作用。这种方法是最古老的，也是最广为人知的，最近几年，通过海因里希·赫兹的研究，这种方法变得尤为突出。另一种方法是使电流通过一个电路，最好是包围很大面积的一个电路，从而在位于远处的一个类似电路中感应出另一个电流，并以任何方便的方式影响一个接收装置。还有另一种方法，也是多年来已知的，是以任何合适的方式使电流通过一部分地面，例如将一个发电机的两个终端通过连接地面的两个点，最好是相距很远的两个点，并通过地面来扩散一部分电流来激励远处的一个电路，该电路类似于布置并在相距很远的两个点接地，这两个点作用在一个灵敏的接收器上。这些不同的方法都有其局限性，尤其是一个普遍存在的局限性，即接收电路或接收仪器必须保持在相对于发射设备的确定位置，这通常给设备的使用带来很大的缺点。

In several applications filed by me and patents granted to me I have disclosed other methods of

accomplishing results of this nature, which may be briefly described as follows: In one system the potential of a point or region of the earth is varied by imparting to it intermittent or alternating electrifications through one of the terminals of a suitable source of electrical disturbances, which, to heighten the effect, has its other terminal connected to an insulated body, preferably of large surface and at an elevation. The electrifications communicated to the earth spread in all directions through the same, reaching a distant circuit which generally has its terminals arranged and connected similarly to those of the transmitting source and operates upon a highly-sensitive receiver. Another method is based upon the fact that the atmospheric air, which behaves as an excellent insulator to currents generated by ordinary apparatus, becomes a conductor under the influence of currents or impulses of enormously high electromotive force, which I have devised means for generating. By such means air strata, which are easily accessible, are rendered available for the production of many desired effects at distances however great. This method, furthermore, allows advantage to be taken of many of those improvements which are practicable in the ordinary systems of transmission involving the use of a metallic conductor.

在我提交的几个申请和授予我的专利中，我已经公开了实现这种性质的结果的其他方法，可以简要描述如下：在一个系统中，大地的某一点或某一区域的电位是通过适当的电扰动源的一个终端向其施加间歇或交变的电流来改变的，为了提高效果，电扰动源的另一个终端连接到一个被绝缘体上，该被绝缘体最好具有较大的表面并位于一个高处。传到大地的电流通过大地向四面八方传播，到达一个远处的电路，该电路的终端一般与发射源的终端有着相似的布局 and 连接，并通过一个高灵敏度的接收器工作。另一种方法是基于这样一个事实，即对于普通设备产生的电流表现为一种优秀的绝缘体的大气空气在非常高的电动势的电流或脉冲的影响下变成一种导体，我已经设计了产生这种极高电动势的工具。通过这种工具，容易接近的空气层可被用于在不同距离上产生许多所需的效果，无论距离有多远。此外，这种方法允许利用在涉及使用金属导体的普通传输系统中可行的许多改进。

Obviously whatever method be employed it is desirable that the disturbances produced by the transmitting apparatus should be as powerful as possible, and by the use of certain forms of high-frequency apparatus, which I have devised and which are now well known, important practical advantages are in this respect secured. Furthermore, since in most cases the amount of energy conveyed to the distant circuit is but a minute fraction of the total energy emanating from the source it is necessary for the attainment of the best results that whatever the character of the receiver and the nature of the disturbances as much as possible of the energy conveyed should be made available for the operation of the receiver, and with this object in view I have heretofore, among other means, employed a receiving-circuit of high self-induction and very small resistance and of a period such as to vibrate in synchronism with the disturbances, whereby a number of separate impulses from the source were made to cooperate, thus magnifying the effect exerted upon and insuring the action of the receiving device. By these means decided advantages have been secured in many instances; but very often the improvement is either not applicable at all, or, if so, the gain is very slight. Evidently when the source is one producing a continuous pressure or delivering impulses of long duration it is impracticable to magnify the effects in this manner, and when, on the other hand, it is one furnishing short impulses of extreme rapidity of succession the advantage obtained in this way is insignificant, owing to the radiation and the unavoidable frictional waste in the receiving-circuit. These losses reduce greatly both the intensity and the number of the cooperative impulses, and since the initial intensity of each of these is necessarily limited only an insignificant amount of energy is thus made available for a single operation of the receiver. As this amount is consequently dependent on the energy conveyed to the receiver by one single impulse, it is

evidently necessary to employ either a very large and costly, and therefore objectionable, transmitter, or else to resort to the equally objectionable use of a receiving device too delicate and too easily deranged. Furthermore, the energy obtained through the cooperation of the impulses is in the form of extremely rapid vibrations and because of this unsuitable for the operation of ordinary receivers, the more so as this form of energy imposes narrow restrictions in regard to the mode and time of its application to such devices. To overcome these and other limitations and disadvantages that have heretofore existed in such systems of transmission of signals or intelligence and to render possible an investigation of impulses or disturbances propagated through the natural media from any kind of source and their practical utilization for any purpose to which they are applicable, I have devised a novel method, which I have described in a pending application filed June 24, 1899, Serial No. 721,790, and which, broadly stated, consists in effecting during any desired time interval a storage of energy derived from such impulses and utilizing the potential energy so obtained for operating a receiving device.

显然，无论采用什么方法，都希望由发射装置产生的扰动尽可能的强，并且通过使用我已经设计的并且现在众所周知的某些形式的高频装置，在这方面确保了重要的实际优点。此外，由于在大多数情况下，传送到远处电路的能量只是从源头发出的总能量的很小一部分，所以为了获得最佳结果，无论接收器的特性和扰动的性质如何，都应该使尽可能多的传送能量可用于接收器的操作，鉴于这个目的，我迄今为止在其他工具中采用了一个具有高自感和非常小的电阻的接收电路，且该电路的周期使其能与扰动同步振动，由此来自源头的许多单独的脉冲被迫协作，从而放大影响并确保接收设备的作用。通过这些工具，在许多情况下都获得了明显的优势；但很多时候，这种改进要么根本不适用，要么就算适用，收益也非常小。显然，当源头是一个产生连续压力或传递长时间脉冲的源头时，用这种方式放大效果是不切实际的，而另一方面，当源头是一个提供极端快速连续的短脉冲的源头时，由于辐射和接收电路中不可避免的摩擦损耗，以这种方式获得的优势也是微不足道的。这些损耗大大降低了协同脉冲的强度和数量，并且由于这些协同脉冲的每一个的初始强度必然是有限的，因此只有少量的能量可用于接收器的单次操作。由于这个量因此依赖于由一个单个脉冲传送到接收器的能量，显然有必要使用非常大，并且昂贵，因此令人讨厌的发射器，或者求助于同样令人讨厌的使用过于精密且太容易混乱的接收装置。此外，通过脉冲协作获得的能量是以极快振动的形式存在的，因此不适合普通接收器的操作，尤其是这种形式的能量对于应用此能量的设备的模式和时间有着严格的限制。为了克服迄今为止在这种信号或情报传输系统中存在的这些和其它限制和缺点，并使研究从任何种类的源头通过自然媒介传播的脉冲或扰动及其应用于任何目的的实际应用成为可能，我设计了一种新颖的方法，我在1899年6月24日提交的未决申请721,790中描述了这种方法，概括地说，这种方法包括以任何所需的时间间隔实现从这种脉冲中获得的能量的存储，并利用如此获得的势能来操作接收装置。

My present invention is intended for the same general purposes, and it comprises another apparatus by means of which similar results may be obtained.

我的发明旨在用于相同的普遍目的，并且它包括另一种装置，通过该装置可以获得类似的结果。

The chief feature which distinguishes the method of my present from that of my former invention, just referred to, is that the energy stored is not, as in the former instance, obtained from the energy of the disturbances or effects transmitted from a distance, but from an independent source.

我当前的方法与我以前的发明的方法的主要区别在于，正如前面提到的，储存的能量不是从远处传输的扰动或影响的能量中获得的，而是从一个独立的来源获得的。

Expressed generally, the present method consists in charging a storage device with energy from an independent source, controlling the charging of said device by the action of the effects or disturbances transmitted through the natural media, and coincidentally using the stored energy for operating a receiving device.

总的来说，当前的方法在于利用来自一个独立源头的能量对一个存储设备进行充电，该独立源通过自然媒介传输的效应或扰动的作用来控制所述设备的充电，并且同时使用存储的能量来操作一个接收设备。

A great variety of disturbances, produced either by suitably-constructed transmitters or by natural causes, are at present known to be propagated through the natural media, and there are also a variety of means or devices enabling energy to be stored, and in view of this I wish to say that I consider the utilization of any such disturbances and the employment of any of these means as within the scope of my present invention so long the use of the general methods hereinbefore stated is involved.

目前已知由适当构造的发射器或自然原因产生的各种各样的扰动可通过自然媒介传播，并且还有各种能够存储能量的工具或设备，鉴于此，我想说，我认为任何这种扰动的利用和任何这些工具的使用都在我的发明的范围内，只要涉及使用上文所述的通用方法。

The best way of carrying out my invention which I at present know is to store electrical energy obtained from a suitable electrical generator in a condenser and to control the storage on the application of this energy by means of a sensitive device acted upon by the effects or disturbances, and thereby cause the operation of the receiver.

我目前所知的实施我的发明的最佳方式是将从合适的发电机获得的电能存储在电容器中，并通过受影响或扰动作用的一个敏感装置控制该能量的存储，从而使接收器工作。

In the practical application of this method I usually proceed as follows: At any point where I desire to investigate or to utilize for any purpose effects or disturbances propagated through the natural media from any kind of source I provide a suitable generator of electricity—as, for example, a battery and a condenser—which I connect to the poles of the generator in series with a sensitive device capable of being modified in its electrical resistance or other property by the action of the disturbances emitted from the source. To the terminals of the condenser I connect the receiver which is to be operated in series with another device of suitable construction, which performs the function of periodically discharging the condenser through the receiver at and during such intervals of time as may be best suitable for the purpose contemplated. This latter device may merely consist of two stationary electrodes separated by a feeble dielectric layer of minute thickness, but sufficient to greatly reduce or practically interrupt the current in the circuit under normal conditions, or it may comprise terminals one or more of which are movable and actuated by any suitable force and are adapted to be brought into and out of contact with each other in any convenient manner. The sensitive device may be any of the many devices of this kind which are known to be affected by the disturbances, impulses, or effects propagated through the media, and it may be of such a character that normally—that is, when not acted upon—it entirely

prevents the passage of electricity from the generator to the condenser, or it may be such that it allows a gradual leaking through of the current and a charging of the condenser at a slow rate. In any case it will be seen that if the disturbances, of whatever nature they may be, cause an appreciable diminution in the electrical resistance of the sensitive device the current from the battery will pass more readily into the condenser, which will be charged at a more rapid rate, and consequently each of its discharges through the receiver, periodically effected by the special device before referred to which performs this function, will be stronger than normally—that is, when the sensitive device is not acted upon by the disturbances. Evidently then if the receiver be so adjusted that it does not respond to the comparatively feeble normal discharges of the condenser, if they should occur, but only to those stronger ones which take place upon the diminution of the resistance of the sensitive device it will be operated only when this device is acted upon by the disturbances, thus making it possible to investigate and to utilize the latter for any desired purpose.

在这种方法的实际应用中，我通常如下进行：在我希望调查或利用通过自然媒介传播的任何种类来源的影响或扰动以达到任何目的的任何点上，我配备了一台合适的发电机——例如，一个电池和一个电容器——我将它与发电机的电极和一个敏感装置串联，该敏感装置能够通过从源头发出的扰动的作用来改变其电阻或其他属性。将接收器连接到电容器 I 的不同终端，该接收器将与另一个具有合适结构的装置串联操作，该装置以最适合预期目的的时间间隔或在最适合预期目的的时间间隔期间执行通过接收器周期性地使电容器放电的功能。后一种装置可以仅由两个静态电极组成，这两个固定电极由微小厚度的弱介电层隔开，但是足以在正常条件下极大地削弱或实际上中断电路中的电流，或者它可以包含终端，其中一个或多个终端是可移动的，并且由任何合适的力驱动，并且适于以任何方便的方式彼此接触和脱离接触。敏感装置可以是已知的受扰动、脉冲或通过媒介传播的效应所影响的许多这类装置中的任何一种，并且它可以具有这样的特性，即在正常情况下——也就是说，当不被施加作用时——它完全阻止电力从发电机传递到电容器，或者它可以是这样的，即它允许电流逐渐泄漏并以缓慢的速率对电容器充电。在任何情况下，可以看出，如果扰动(无论其性质如何)导致敏感设备的电阻明显减小，则来自电池的电流将更容易进入电容器，电容器将以一个更快的速率充电，因此其通过接收器的每一次放电(由前面提到的执行该功能的特殊设备周期性地影响)将比正常情况更强，也就是说，当敏感设备没有受到扰动作用时。显然，那么，如果接收器被调整到不能响应电容器的相对微弱的正常放电，如果它们应该发生，但只响应那些在敏感装置的电阻减小时发生的更强的放电，它将只在这个设备受到扰动时操作，使得研究和利用后者用于任何期望的目的成为可能。

The general principle underlying my invention and the operation of the various devices used will be clearly understood by reference to the accompanying drawings, in which—

通过参考附图，将会清楚地理解本发明的基本原理和所使用的各种设备的操作，其中—

Figure 1 is a diagram illustrating a typical arrangement of apparatus which may be used in carrying my method into practice, and Figs. 2, 3, 4, and 5 similar diagrams of modified arrangements of apparatus for the same purpose.

图 1 是说明可用于实施我的方法的装置的典型布置的示意图，图 2、3、4 和 5 是用于相同目的的装置的改进布置的示意图。

In Fig. 1, C is a condenser, to the terminals T and T' of which is connected a charging-circuit including a battery B, a sensitive device a, and a resistance r, all connected in series, as illustrated. The battery should be preferably of very constant electromotive force and of an intensity carefully determined to secure the best results. The resistance r, which may be a frictional or an inductive one, is not absolutely necessary; but it is of advantage to use it in order to facilitate adjustment, and for this purpose it may be made variable in any convenient and preferably continuous manner. Assuming that the disturbances which are to be investigated or utilized for some practical end are rays identical with or resembling those of ordinary light, the sensitive device a may be a selenium cell properly prepared, so as to be highly susceptible to the influence of the rays, the action of which should be intensified by the use of a reflector A. (Shown in the drawings.) It is well known that when cells of this kind are exposed to such rays of greatly-varying intensity they undergo corresponding modifications of their electrical resistance; but in the ways they have been heretofore used they have been of very limited utility.

在图 1 中, C 是一个电容器, 它的终端 T 和 T' 连接到一个充电电路, 该充电电路包括一个电池 B、一个敏感装置 a 和一个电阻 r, 如图所示, 它们都串联连接。该电池应该优选地具有非常恒定的电动势和一个仔细确定的强度, 以确保最佳结果。电阻 r 可以是一个摩擦电阻或电感电阻, 但并不是绝对必要的; 但是使用它是有利的, 以便于调节, 并且为此目的, 它可以被制成以任何方便的并且优选连续的方式变化。假设要研究或用于某些实际目的的扰动是与普通光相同或相似的光线, 敏感器件 a 可以是适当制备的一个硒电池, 以便对光线的影响高度敏感, 其作用应该通过使用一个反射器 A 来加强, 如图所示。众所周知, 当这种电池暴露于这种强度变化很大的射线时, 它们的电阻会发生相应的变化; 但是在迄今为止它们的使用方式中, 它们的效用非常有限。

In addition to the circuit including the sensitive device or cell a another circuit is provided, which is likewise connected to the terminals T T' of the condenser. This circuit, which may be called the "receiving-circuit," includes the receiver R and in series with it a device d, before referred to, which performs the duty of periodically discharging the condenser through the receiver. It will be noted that, as shown in Fig. 1, the receiving-circuit is in permanent connection with the battery and condenser-terminal T, and it should be stated that it is sometimes desirable to entirely insulate the receiving-circuit at all times, except the moments when the device d operates to discharge the condenser, thus preventing any disturbing influence which might otherwise be caused in this circuit by the battery or the condenser during the period when the receiver should not be acted upon. In such a case two devices, as d, may be used, one in each connection from the condenser to the receiving-circuit, or else one single device of this kind, but of a suitably-modified construction, so that it will make and break simultaneously and at proper intervals of time both of the connections of this circuit with the condenser T and T'.

除了包括敏感器件或电池 a 的电路之外, 还提供了另一个电路, 它同样连接到电容器的终端 T T'。该电路可以被称为“接收电路”, 包括接收器 R 和与其串联的一个装置 d, 该装置通过该接收器执行周期性地使电容器放电的任务。应该注意的是, 如图 1 所示, 接收电路与电池和电容器终端 T 永久连接, 并且应该指出的是, 除了装置 d 操作使电容器放电的时刻之外, 有时希望在所有时间完全隔离接收电路, 从而防止在接收器不被操作的期间, 电池或电容器可能在该电路中引起的任何干扰影响。在这种情况下, 可以使用两个装置, 如 d, 从电容器到接收电路的每个连接中都有一个, 或者这种类型的一个单独的装置, 但是具有适当修改的结构, 这样它将以适当的时间间隔同时接通和断开该电路与电容器 T 和 T' 的两个连接。

From the foregoing the operation of the apparatus, as illustrated in Fig. 1, will be at once understood. Normally—that is, when it is not influenced by the rays at all or very slightly—the cell a, being of a comparatively high resistance, permits only a relatively feeble current to pass from the battery into the condenser, and hence the latter is charged at too slow a rate to accumulate during the time interval between two succeeding operations of the device d sufficient energy to operate the receiver or, generally speaking, to produce the required change in the receiving-circuit. This condition is readily secured by a proper selection and adjustment of the various devices described, so that the receiver will remain unresponsive to the feeble discharges of the condenser which may take place when the cell a is acted upon but slightly or not at all by the rays or disturbances; but if now new rays are permitted to fall upon the cell or if the intensity of those already acting upon it be increased by any cause then its resistance will be diminished and the condenser will be charged by the battery at a more rapid rate, enabling sufficient potential energy to be stored in the condenser during the period of inaction of the device d to operate the receiver or to bring about any desired change in the receiving-circuit when the device d acts. If the rays acting upon the cell or sensitive device a are varied or intermitted in any arbitrary manner, as when transmitting intelligence in the usual way from a distant station by means of short and long signals, the apparatus may readily be made to record or to enable an operator to read the message, since the receiver—supposing it to be an ordinary magnetic relay, for example—will be operated by each signal from the sending-station a certain number of times, having some relation to the duration of each signal. It will be readily seen, however, that if the rays are varied in any other way, as by impressing upon them changes in intensity the succeeding condenser-discharges will undergo corresponding changes in intensity, which may be indicated or recorded by a suitable receiver and distinguished irrespectively of duration.

根据前述内容，将立刻理解如图 1 所示的设备的操作。正常情况下——也就是说，当它完全不受射线影响或非常轻微地受射线影响时——具有相对较高电阻的电池 a 只允许相对较弱的电流从电池进入电容器，因此电容器以太慢的速率充电，以至于在设备 d 的两个连续操作之间的时间间隔期间不能积累足够的能量来操作接收器，或者一般来说，不能在接收电路中产生所需的变化。这一条件很容易通过所述各种设备的一个适当选择和调整来保证，因此接收器将对电容器的微弱放电保持无响应，这种微弱放电可以在电池 a 受到光线或扰动作用时发生，但这种作用太轻微或根本毫无作用；但是如果现在允许新的射线落在电池上，或者如果那些已经作用在电池上的射线的强度由于任何原因而增加，那么它的电阻将减小，并且电容器将由电池以更快的速率充电，使得在设备 d 不工作期间有足够的势能存储在电容器中，以操作接收器，或者当设备 d 工作时在接收电路中产生任何期望的变化。如果作用在电池或敏感装置 a 上的射线以任意方式变化或中断，如当以通常的方式通过短信号和长信号从远处的站发送信息时，该装置可以容易地记录或使操作者能够阅读信息，因为接收器，例如假设它是一个普通的磁继电器，将由来自发送站的每个信号操作一定次数，这与每个信号的持续时间有一定关系。然而，很容易看出，如果射线以任何其他方式变化，如通过在其上施加强度变化，随后的电容器放电将经历相应的强度变化，这可以由合适的接收器指示或记录，并与持续时间无关。

With reference to Fig. 1 it may be useful to state that the electrical connections of the various devices illustrated may be made in many different ways. For instance, the sensitive device instead of being in series, as shown, may be in a shunt to the condenser, this modification being illustrated in Fig. 3, in which the devices already described are indicated by similar letters to correspond with those of Fig. 1. In this case it will be observed that the condenser, which is being charged from the battery B through

the resistance r , preferably inductive and properly related to the capacity of the condenser, will store less energy when the sensitive device a is energized by the rays, and its resistance thereby diminished. The adjustment of the various instruments may then be such that the receiver will be operated only when the rays are diminished in intensity or interrupted and entirely prevented from falling upon the sensitive cell, or the sensitive device may be placed, as shown in Fig. 4, in a shunt to the resistance r or inserted in any suitable way in the circuit containing the receiver—for example, as illustrated in Fig. 5—in both of which figures the various devices are lettered to correspond with those in Fig. 1, so that the figures become self-explanatory. Again, the several instruments may be connected in the manner of a Wheatstone bridge, as will be hereinafter explained with reference to Fig. 2, or otherwise connected or related; but in each case the sensitive device will have the same duty to perform—that is, to control the energy stored and utilized in some suitable way for causing the operation of the receiver in correspondence with the intermittences or variations of the effects or disturbances—and in each instance by a judicious selection of the devices and careful adjustment the advantages of my method may be more or less completely secured. I find it preferable, however, to follow the plan which I have illustrated and described.

参考图 1, 说明所示的各种设备的导电连接可以以许多不同的方式进行可能是有用的。例如, 如图所示, 敏感装置不是串联的, 而是可以与电容器并联, 这种修改在图 3 中示出, 其中已经描述的装置用与图 1 中对应的类似字母表示。在这种情况下, 可以观察到, 当敏感装置 a 被射线激励时并且它的电阻明显降低, 这时通过电阻 r 从电池 B 充电的电容器将存储较少的能量, 电阻 r 最好是电感性的, 并与电容器的容量适当相关。然后, 各种仪器的调整可以是这样的, 即接收器将仅在射线强度减弱或被中断并完全被阻止落在敏感电池上时才工作, 或者敏感装置可以如图 4 所示被放置在电阻 r 的分流器中, 或者以任何适合的方式被插入包含接收器的电路中——例如, 如图 5 所示——在这两个图中, 各种装置被标上字母以与图 1 中的对应, 从而这些图变得不言而喻。同样, 几个仪器可以以惠斯通电桥的方式连接, 如将在下文中参考图 2 解释的, 或者以其他方式连接或相关; 但在每一种情况下, 敏感设备将有相同的职责来执行——也就是说, 以某种适当的方式控制能量的存储和利用, 使接收器的操作与影响或扰动的间断性或变化相对应, 在每一种情况下, 通过明智地选择设备和仔细调整, 可以或多或少完全确保我的方法的优点。然而, 我发现更好的是遵循我已经说明和描述的方案。

It will be observed that the condenser is an important element in the combination. I have shown that by reason of its unique properties it greatly adds to the efficacy of this method. It allows the energy accumulated in it to be discharged instantaneously, and therefore in a highly effective manner. It magnifies in a large degree the current supplied from the battery, and owing to these features it permits energy to be stored and discharged at practically any rate desired, and thereby makes it possible to obtain in the receiving-circuit very great changes of the current strength by impressing upon the battery-current very small variations. Other means of storage possessing these characteristics to a useful degree may be employed without departing from the broad spirit of my invention; but I prefer to use a condenser, since in these respects it excels any other storage device of which I have knowledge. In Fig. 2 a modified arrangement of apparatus is illustrated which is particularly adapted for the investigation and utilization of very feeble impulses or disturbances, such as may be used in conveying signals or producing other desired effects at very great distances. In this case the energy stored in the condenser is passed through the primary of a transformer, the secondary circuit of which contains the receiver, and in order to render the apparatus still more suitable for use in detecting feeble impulses, in addition to the sensitive device

which is acted upon by the impulses, another such device is included in the secondary circuit of the transformer. The scheme of connections is in the main that of a Wheatstone bridge, the four branches of which are formed by the sensitive device *a* and resistances *L*, *L'*, and *L''*, all of which should be preferably inductive and also adjustable in a continuous manner, or at least by very small steps. The condenser *C'*, which is generally made of considerable capacity, is connected to two opposite points of the bridge, while a battery *B*, in series with a continuously-adjustable non-inductive resistance *r'*, is connected to the other pair of opposite points, as usual. The four resistances included in the branches of the bridge—namely, *a*, *L*, *L'*, and *L''*—are of a suitable size and so proportioned that under normal conditions—that is, when the device *a* is not influenced at all or only slightly by the disturbances—there will be no difference of potential, or, in any case, the minimum of the same at the terminals *T* and *T'* of the condenser. It is assumed in the present instance that the disturbances to be investigated or utilized are such as will produce a difference of electrical potential, however small, between two points or regions in the natural media, as the earth, the water, or the air, and in order to apply this potential difference effectively to the sensitive device *a* the terminals of the same are connected to two plates *P* and *P'*, which should be of as large a surface as practicable and so located in the media that the largest possible difference of potential will be produced by the disturbances between the terminals of the sensitive device. This device is in the present case one of familiar construction, consisting of an insulating-tube, which is indicated by the heavy lines in the drawings and which has its ends closed tightly by two conducting-plugs with reduced extensions, upon which bear two brushes *b b*, through which the currents are conveyed to the device. The tubular space between the plugs is partially filled with a conducting sensitive powder, as indicated, the proper amount of the same and the size of its grains being determined and adjusted beforehand by experiment. This tube *I* rotate by clockwork or other means at a uniform and suitable rate of speed, and under these conditions I find that this device behaves toward disturbances of the kind before assumed in a manner similar to that of a stationary cell of selenium toward rays of light. Its electrical resistance is diminished when it is acted upon by the disturbances and is automatically restored upon the cessation of their influence. It is of advantage to employ round grains of powder in the tube, and in any event it is important that they should be of a uniform size and shape as possible and that provision should be made for maintaining an unchanging and very dry atmosphere in the tube. To the terminals *T* and *T'* of the condenser *C'* is connected a coil *p*, usually consisting of a few turns of a conductor of very small resistance, which is the primary of the transformer before referred to, in series with a device *d*, which effects the discharge of the condenser through the coil *p* at predetermined intervals of time. In the present case this device consists of a cylinder made partly of conducting and partly of insulating material *e* and *e'*, respectively, which is rotated at the desired rate of speed by any suitable means. The conducting part *e* is in good electrical connection with shaft *S* and is provided with tapering segments, as *f*, upon which slides a brush *k*, which should preferably be capable of longitudinal adjustment along the cylinder. Another brush *b'*, which is connected to the condenser-terminal *T'*, being arranged to bear upon the shaft *S*, it will be seen that whenever the brush *k* comes in contact with a conducting-segment *e* the circuit including the primary *p* will be completed and the condenser, if energized, discharged through the same. By an adjustment of the speed of rotation of the cylinder and a displacement of the brush *k* along the axis of the same the circuit may be made to open and close in as rapid succession and remain open or closed during such intervals of time as may be desired. In inductive relation to the primary *p* is a secondary coil *s*, usually of much thinner wire and of many more turns than the former, to which are connected in a series a receiver *R*, illustrated as an ordinary magnetic relay, a continuously-adjustable non-inductive resistance *r''*, a battery *B''* of a properly-determined and very constant electromotive force, and finally a sensitive

device a' of the same or similar construction as a , which is likewise rotated at a uniform speed and which, with its brushes b' b'' , closes the secondary circuit. The electromotive force of the battery B' is so graduated by means of the adjustable resistance r'' that the dielectric layers in the sensitive device a' are strained very nearly to the point of breaking down and give way upon a slight increase of the electrical pressure on the terminals of the device. It will of course be understood that the resistance r'' is used mainly because of convenience and that it may be dispensed with, in which case the adjustment may be effected in many other ways, as by determining the proper amount or coarseness of the sensitive powder or by varying the distance apart of the metallic plugs in the ends of the tube. The same may be said of the resistance r' , which is in series with the battery B and serves to graduate the force of the latter, so that the dielectric layers of the sensitive device a are subjected to a similar strain and maintained in a state of delicate poise. The various instruments being connected and adjusted in the manner described, it will now be readily seen from the foregoing that under normal conditions, the device a being unaffected by the disturbances, or practically so, and there being no or only a very insignificant amount of energy stored in the condenser, the periodical closure of the primary circuit of the transformer through the operation of the device d will have no appreciable effect upon the primary coil p , and hence no currents will be generated in the secondary coil s , at least not such as would disturb the state of delicate balance existing in the secondary circuit including the receiver, and therefore the latter will not be actuated by the battery B' ; but when, owing to the disturbances or impulses propagated through the media from a distant source, an additional electromotive force, however small, is created between the terminals of the device a the dielectric layers in the same, unable to support the increased strain, give way and allow the current of the battery B to pass through, thus causing a difference of potential at the terminals T and T' of the condenser. A sufficient amount of energy being now stored in this instrument during the time interval between each two succeeding operations of the device d , each closure of the primary circuit by the latter results in the passage of a sudden current impulse through the coil p , which induces a corresponding current of relatively high electromotive force in the secondary coil s . Owing to this the dielectric in the device a' gives way, and the current of the battery B' being allowed to pass the receiver R is operated, but only for a moment, since by the rotation of the devices a , a' , and d , which may be all driven from the same shaft, the original conditions are restored, assuming, of course, that the electromotive force set up by the disturbances at the terminals of the sensitive device a is only momentary or of a duration not longer than the time of closure of the primary circuit; otherwise the receiver will be actuated a number of times and so long as the influence of the disturbances upon the device a continues. In order to render the discharged energy of the condenser more effective in causing the operation of the receiver, the resistance of the primary circuit should be very small and the secondary coil s should have a number of turns many times greater than that of the primary coil p . It will be noted that since the condenser under the above assumptions is always charged in the same direction the strongest current impulse in the secondary coil, which is induced at the moment when the brush k comes in contact with segment e , is also of unchanging direction, and for the attainment of the best results it is necessary to connect the secondary coil so that the electromotive force of this impulse will be added to that of the battery and will momentarily strengthen the same. However, under certain conditions, which are well understood by those skilled in the art, the devices will operate whichever way the secondary be connected. It is preferable to make the inductive resistances L and L' relatively large, as they are in a shunt to the device a and might, if made too small, impart its sensitiveness. On the other hand, the resistance L'' should not be too large and should be related to the capacity of the condenser and the number of makes and breaks effected by the device d in well-known ways. Similar considerations apply, of course, to the circuits including the primary p and secondary s , respectively.

可以看出,电容器是组合中的一个重要组件。我已经表明,由于其独特的性质,它大大增加了这种方法的效率。它允许积聚在其中的能量瞬间释放,因此以高效的方式释放。它在很大程度上放大了电池提供的电流,并且由于这些特征,它允许能量以实际上任何期望的速率存储和放电,并且由此使得通过在电池电流上施加非常小的变化而在接收电路中获得电流强度的非常大的变化成为可能。在不脱离本发明的广义精神的情况下,可以使用在有用程度上拥有这些特征的其他存储工具;但我更喜欢使用电容器,因为在这些方面,它优于我所知道的其他任何存储设备。在图2中,展示出了装置的一个改进布置,其特别适于研究和利用非常微弱的脉冲或扰动,例如可以用于在非常远的距离上传送信号或产生其他期望的效果。在这种情况下,储存在电容器中的能量经过一个变压器的初级,变压器的次级电路包含接收器,为了使该设备更适合用于检测微弱的脉冲,除了由脉冲作用的敏感装置之外,在变压器的次级电路中还包括另一个这样的装置。连接方案主要是一个惠斯通电桥,惠斯通电桥的四个分支由敏感器件a和电阻L、L'和L"形成,所有这些最好是电感性的,并且也可以以连续的方式或至少以非常小的步长进行调节。通常由相当大的电容量制成的电容器C'连接到电桥的两个相对点,而与连续可调的无感电阻r'串联的电池B通常连接到另一对相对点。电桥支路中包含的四个电阻(即a、L、L'和L")具有适当的大小和比例,使得在正常情况下(即,当设备a完全不受扰动影响或仅轻微受影响影响时),在电容器的终端T和T'处不会有电位差,或者在任何情况下电位差最小。在本实例中,假设待研究或待利用的扰动将在自然媒介(如大地、水或空气)中的两点或区域之间产生电势差,无论该电势差有多小,并且为了将该电势差有效地施加到敏感设备a,该设备的终端分别连接到两个板P和P',其应当具有一个尽可能大的表面,并且位于媒介中,使得敏感装置的终端之间的扰动将产生最大可能的电势差。在本例中,这种装置是一种常见的结构,由一个绝缘管组成,绝缘管在图中用粗线表示,其端部由两个导电塞紧密封闭,导电塞具有减小的延伸部分,导电塞上带有两个电刷bb,电流通过电刷bb传送到装置。如图所示,导电塞之间的管状空间部分填充有导电敏感粉末,导电敏感粉末的适当量及其颗粒的尺寸通过实验预先确定和调整。我旋转发条或其他工具让这个管在一个均速的和适当的速度,在这些条件下,我发现这个装置对前面假设的那种扰动的反应方式类似于一个静态的硒电池对光线的反应方式。当受到扰动作用时,它的电阻减小,当扰动停止时,它的电阻自动恢复。在管中使用圆形粉末颗粒是有优势的,并且在任何情况下,重要的是它们应该具有尽可能均匀的尺寸和形状,并且应该采取措施来保持管中不变的和非常干燥的环境。电容器C'的终端T和T'与一个线圈p相连,线圈p通常由几匝电阻很小的导体组成,它是上述变压器的初级,与装置d串联,装置d以预定的时间间隔通过线圈p使电容器放电。在这种情况下,该装置包括一个圆筒,一部分由导电材料c制成和一部分由绝缘材料和c'制成,该圆筒通过任何合适的工具以所需的速度旋转。导电部分c与轴S具有良好的电连接,并设有锥形分段e,一个电刷k在锥形分段e上滑动,电刷k最好能够沿圆筒纵向调节。另一个电刷b',连接到电容器终端T'上,布置成倚靠在轴S上,可以看到,每当电刷k与导电分段e接触时,包括初级线圈p的电路将被接通,电容器如果已充电,将通过该电路放电。通过调节圆筒的转速和电刷k沿其轴线的位移,可以使电路快速连续地断开和闭合,并在所需的时间间隔期间保持断开和闭合。与初级线圈p成感应关系的是次级线圈s,通常具有比初级线圈细得多的导线和多得多的匝数,初级线圈p串联有接收器R(图示为普通的磁继电器)、一个连续可调的无感电阻r"、一个具有适当确定且非常恒定电动势的电池B",以及最后具有与a相同或相似结构的敏感装置a',敏感装置a'同样以均匀的速度旋转,并且利用其电刷b'b"闭合次级电路。电池B'的电动势通过可调电阻r"逐渐增加,使得敏感装置a'中的介电层的应变非常接近于击穿点,并且在该装置终端上的电压稍微增加时就会击穿。当然可以理解,使用电阻r'主要是为了方便,并且可以省去电阻r",在这种情况下,可以通过许多其它方式来实现调节,例如通过确定适合量或粗糙度的敏感粉末,或者通过改变管子端部的金属塞之间的距离。电阻r'也是如此,它与电池B串联,用于以这样的方式增

加电池 B 的强度，使得敏感装置 a 的介电层受到类似的应变，并保持在一微妙平衡状态。以所述方式连接和调节各种仪器，现在从前述内容中可以容易地看出，在正常条件下，装置 a 不受扰动的影响，或者实际上如此，并且在电容器中没有或者只有非常少量的能量存储，通过装置 d 的操作，变压器的初级电路的周期性闭合对初级线圈 p 没有明显的影响，因此在次级线圈 s 中不会产生电流，至少不会干扰包括接收器在内的次级电路中存在的微妙平衡状态，因此后者不会被电池 B' 激励；但是，当由于从远处源头通过媒介传播的扰动或脉冲，在装置 a 的终端之间产生一个额外的电动势时，无论该电动势多么小，该装置中的电介质层都不能承受增加的应变，从而使电池 B 的电流通过，从而在电容器的终端 T 和 T' 处产生电位差。现在，在设备 d 的每两次连续操作之间的时间间隔期间，足够量的能量存储在该仪器中，后者每次闭合初级电路 d 都会导致突然的电流脉冲通过线圈 p，这会引起次级线圈 s 中相应的具有较高电动势的电流。由于这一点，装置 a' 中的电介质让出通路，电池 B' 的电流被允许通过接收器 R 来操作，但这只是一个瞬间，因为通过装置 a、a' 和 d 的旋转，它们可以都是由同一轴驱动的，原始状态被恢复，当然，假设由敏感装置 a 的终端处的扰动建立的电动势只是瞬间的或持续时间不长于初级电路闭合的时间；否则，只要扰动对设备 a 的影响持续，接收器将被启动多次。为了使电容器释放的能量更有效地使接收器工作，初级电路的电阻应该非常小，次级线圈 s 的匝数应该比初级线圈 p 的匝数大许多倍。应该注意到，由于在上述假设下电容器总是以相同的方向充电，当电刷 k 与分段 c 接触时，在次级线圈中被感应出的最强电流脉冲也是不变的方向，为了获得最佳结果，有必要连接次级线圈，使得该脉冲的电动势将被加到电池的电动势上，并瞬间增强电池的电动势。然而，在本领域技术人员熟知的某些条件下，无论次级以何种方式连接，设备都将运行。最好使感性电阻 L 和 L' 相对较大，因为它们与设备 a 并联，如果太小，会损害其灵敏度。另一方面，电阻 L'' 不应该太大，并且应该与电容器的容量以及由装置 d 以众所周知的方式实现的接通和断开的次数有关。当然，类似的考虑也适用于分别包括初级 p 和次级 s 的电路。

By carefully observing well-known rules of scientific design and adjustment of the instruments the apparatus may be made extremely sensitive and capable of responding to the feeblest influences, thus making it possible to utilize impulses or disturbances transmitted from very great distances and too feeble to be detected or utilized in any of the ways heretofore known, and on this account the method here described lends itself to many scientific and practical uses of great value.

通过仔细观察装置的科学设计和调整的众所周知的规则，该装置可以非常敏感，能够响应最微弱的影响，从而使利用从非常远的距离传输的脉冲或扰动成为可能，这些脉冲或扰动太弱而不能以迄今已知的任何方式检测或利用，因此这里描述的方法有助于许多具有重大价值的科学和实际应用。

Obviously the character of the devices and the manner in which they are connected or related may be greatly varied without departing from the spirit of my invention.

显然，在不脱离本发明的精神的情况下，设备的特征以及它们连接或相关的方式可以有很大的变化。

What I claim as new, and desire to secure by Letters Patent, is—

我主张的是新的，并希望通过专利证书来保护的是—

1. In an apparatus for utilizing effects or disturbances transmitted through the natural media from a distant source, the combination of an electrical storage device, a charging-circuit connected therewith and including a device sensitive to the action of the effects or disturbances and determining under their control the flow of current in the charging-circuit, a receiving-circuit including a receiver, and means for periodically discharging the storage device through the receiving-circuit, substantially as described.

1、在一种用于利用从远处来源通过自然媒介传输的效应或扰动的设备中的一种组合，它包括一个电存储装置；与之连接的一个充电电路；该充电电路包括一个对这种效应或扰动的作用敏感的装置，并在它们的控制下决定充电电路中的电流；还包括一个接收电路，该电路包含一个接收器以及用于通过该接收电路周期性地对存储设备进行放电的装置方法，基本如上所述。

2. In an apparatus for utilizing effects or disturbances transmitted through the natural media from a distant source, the combination of a condenser, a charging-circuit connected therewith and including a source of electricity and a device sensitive to the action of the effects or disturbances and determining under their control the flow of current in the charging-circuit, a receiving-circuit including a receiver, and means for periodically discharging the condenser through the receiving-circuit, substantially as described.

2、在一种用于利用从远处来源通过自然媒介传输的效应或扰动的设备中的一种组合，它包括一个电存储装置；与之连接的一个充电电路，该充电电路包括一个对这种效应或扰动的作用敏感的装置，并在它们的控制下决定充电电路中的电流；还包括一个接收电路，该电路包含一个接收器以及用于通过该接收电路周期性地对电容器进行放电的装置方法，基本如上所述。

3. In an apparatus for utilizing effects or disturbances transmitted through the natural media from a distant source, the combination of a circuit including a source of electricity, a storage device adapted to have its resistance reduced when acted upon by the effects or disturbances, with a receiving-circuit connected with the storage device and including a receiver and a device adapted to open and close the receiving-circuit at predetermined intervals of time, substantially as described.

3、在一种用于利用从远处来源通过自然媒介传输的效应或扰动的装置中的一种组合，它包括一个包含了一个电源的电路；一个适于在受到效应或扰动作用时减小其电阻的存储设备；与该存储设备连接的一个接收电路；该接收电路包括一个接收器和适于以预定时间间隔断开和闭合该接收电路的设备，基本上如所述。

4. In an apparatus for utilizing effects or disturbances transmitted through the natural media from a distant source, the combination of a circuit including a source of electricity, a condenser and a device normally of very high resistance but adapted to have its resistance reduced when acted upon by the effects or disturbances, with a receiving-circuit connected with the condenser and including a receiver and a device adapted to open and close the receiving-circuit at predetermined intervals of time, substantially as described.

4、在一种用于利用从远处来源通过自然媒介传输的效应或扰动的装置中的一种组合，它包括一个电源；一个电容器和通常具有很高电阻但当受到效应或扰动作用时其电阻减小的一个

装置；以及一个接收电路，它与该电容器连接并包含了一个接收器和适于以预定时间间隔断开和闭合该接收电路的一个装置，基本上如所述。

5. In an apparatus for utilizing effects or disturbances transmitted from a distant source, the combination of a circuit including a source of electricity, a storage device adapted to be charged thereby and a device, normally of very high resistance but adapted to have its resistance reduced when acted upon by the effects or disturbances, with a receiving-circuit connected with the storage device and including the primary of a transformer and a device adapted to open and close such second circuit at predetermined intervals of time, and a receiver included in the secondary of the transformer, substantially as described.

5、在一种用于利用从远处来源通过自然媒介传输的效应或扰动的装置中的一种组合，它包括一个电源；一个适于被其充电的存储装置和一个通常具有非常高的电阻但适于在受到效应或扰动作用时降低其电阻的装置；还包括一个接收电路，它与该存储装置连接，该接收电路包含一个变压器的初级和适于以预定时间间隔断开和闭合这种变压器的次级电路的装置；以及一个被包含在该变压器的次级中的接收器，基本上如所述。

6. In an apparatus for utilizing effects or disturbances transmitted from a distant source, the combination of an electrical storage device, a charging-circuit connected therewith and including a device sensitive to the action of the effects or disturbances and determining under their control the flow of the current in the charging-circuit, and a receiving-circuit supplied with energy from the storage device and including a receiver and a device sensitive to electrical variations in the receiving-circuit, substantially as described.

6、在一种用于利用从远处来源传输的效应或扰动的装置中的一种组合，它包括一个电存储装置；与之连接的一个充电电路，该充电电路包含一个对效应或扰动的作用敏感并在其控制下决定该充电电路中的电流的装置；还有一个接收电路，它由存储装置提供能量，该接收电路包含一个接收器和对该接收电路中电变化敏感的一个装置，基本上如所述。

7. In an apparatus for utilizing effects or disturbances transmitted through the natural media from a distant source, the combination of a condenser, a charging-circuit connected therewith and including a device sensitive to the action of the effects or disturbances and determining under their control the flow of the current in the charging-circuit, and a receiving-circuit supplied with energy from the condenser and including a receiver and a device sensitive to electrical variations in the receiving-circuit, substantially as described.

7、在一种用于利用从远处来源通过自然媒介传输的效应或扰动的装置中的一种组合，它包括一个电容器；与之连接的一个充电电路，该充电电路包含一个对效应或扰动的作用敏感并在其控制下决定该充电电路中的电流的装置；还有一个接收电路，它由电容器提供能量，该接收电路包含一个接收器和对该接收电路中电变化敏感的一个装置，基本上如所述。

8. In an apparatus for utilizing effects or disturbances transmitted through the natural media from a distant source, the combination of a circuit, an independent local source of electricity included therein, a storage device connected with the said circuit and adapted to receive energy from the said source, a device normally of very high resistance, but adapted to have its resistance reduced when acted upon by

the effects or disturbances, a receiving-circuit connected with the storage device, a transformer, the primary of which is included in said receiving-circuit, a device adapted to open and close the receiving-circuit at predetermined intervals of time, a receiver, and a device, normally of very high resistance, but adapted to have its resistance reduced when acted upon by the effects or disturbances, and included in the secondary circuit of the transformer, as set forth.

8、在一种用于利用从远处来源通过自然媒介传输的效应或扰动的装置中的一种组合，它包括一个电路；一个被包含在其中的独立的局部电源；一个与所述电路连接并适于从所述电源接收能量的存储装置；一个通常具有非常高的电阻但适于在受到效应或扰动作用时降低其电阻的装置；一个与存储装置连接的接收电路；一个变压器，其初级被包括在所述的接收电路中；适于以预定的时间间隔断开和闭合该接收电路的一个装置；一个接收器；以及一个通常具有非常高的电阻，但是适于在受到影响或扰动时减小其电阻的装置，并且被包含在变压器的次级电路中，如前所述。

9. In an apparatus for utilizing effects or disturbances transmitted from a distant source, the combination with a storage device and an independent source of energy for charging the same, of a receiving-circuit connected with the storage device, a device sensitive to the effects or disturbances and determining under their control the flow of current in the receiving-circuit, substantially as set forth.

9、在一种用于利用从远处来源传输的效应或扰动的装置中的一种组合，它包括一个存储装置和一个用于对其充电的独立能量源；一个与该存储装置连接的接收电路；一个对效应或扰动敏感并在其控制下确定所述接收电路中的电流的装置，基本上如前所述。

10. In an apparatus for utilizing effects or disturbances transmitted through the natural media from a distant source, the combination with a storage device and an independent source of energy for charging the same, of a receiving-circuit connected with the storage device, a device sensitive to the effects or disturbances and adapted to have its resistance varied by the action thereon of such effects or disturbances and determining under their control the flow of current in the receiving-circuit, substantially as set forth.

10、在一种用于利用从远处来源通过自然媒介传输的效应或扰动的装置中的一种组合，它包括一个电容器、一个与之连接的充电电路、一个与该充电电路连接的接收电路，一种对效应或扰动敏感的器件，其电阻随效应或扰动的作用而变化，并在它们的控制下决定该接收电路中的电流，基本上如上所述。

11. In an apparatus for utilizing effects or disturbances transmitted from a distant source, the combination of a storage device, a battery or similar independent source of energy for charging the same, a sensitive device adapted to have its resistance varied under the influence of the effects or disturbances, a receiver adapted to be operated by the discharge of the storage device, the sensitive device being in one branch of a Wheatstone bridge, the storage device in one of the cross connections between two opposite points of the bridge, and the battery in the other cross connection, and resistances L , L' and L'' in the three remaining branches of the bridge, as set forth.

11、在一种用于利用从远处来源通过自然媒介传输的效应或扰动的装置中的一种组合，它包括一个存储装置；一个电池或用于对其充电的类似独立电源；一个适于在效应或扰动的影响

下改变其电阻的敏感装置；一个适于由存储装置的放电进行操作的接收器，在一个惠斯通电桥的一个分支中，该敏感装置处在电桥的两个相对点之间的交叉连接之一中，电池处在另一个交叉连接中，电阻 L、L'和 L''处在电桥的三个剩余分支中，如上所述。

12. In an apparatus for utilizing effects or disturbances transmitted through the natural media from a distant source, the combination of a storage device, a battery or like independent source of energy for charging the same, a sensitive device adapted to have its resistance varied under the influence of the effects or disturbances, a circuit connected with the terminals of the storage device, a transformer having its primary in said circuit and a receiver in the secondary circuit of the transformer, the sensitive device being in one branch of a Wheatstone bridge, the storage device in one of the cross connections between opposite points of the bridge and the battery in the other cross connection, and resistances L, L' and L'' in the three remaining branches of the bridge, as set forth.

12、在一种用于利用通过自然媒介从远处来源传输的效应或扰动的装置中的一种组合，它包括一个存储装置、一个电池或类似的用于对其充电的独立能源、一个适于在效应或扰动的影响下改变其电阻的敏感装置、一个与存储装置的终端连接的电路、一个其初级在所述电路中的变压器、一个在该变压器的次级电路中的接收器，敏感装置在一个惠斯通电桥的分支之一中，存储装置在电桥的相对点之间的交叉连接之一中，电池处在另一个交叉连接中，电阻 L、L'和 L''处在电桥的三个剩余分支中。

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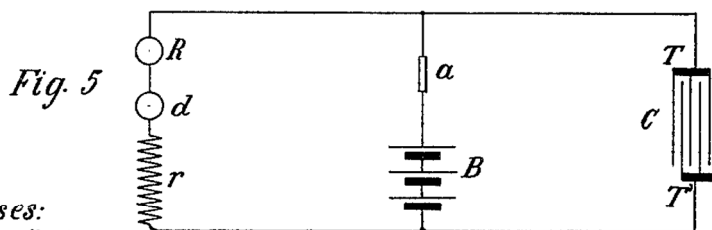
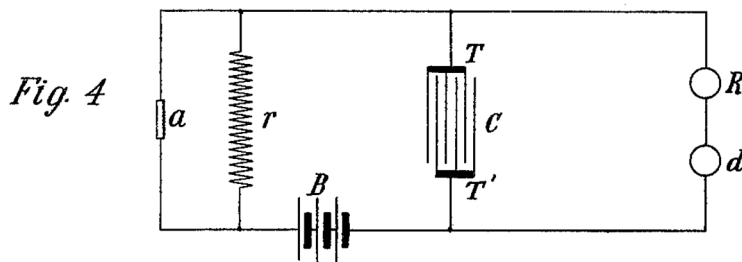
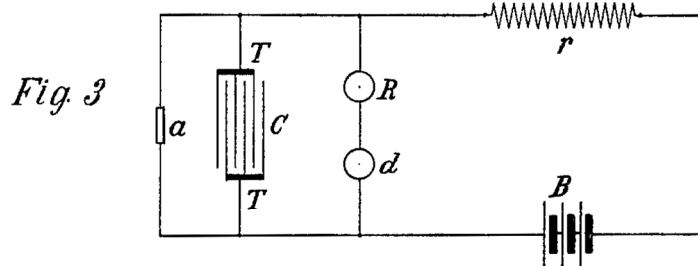
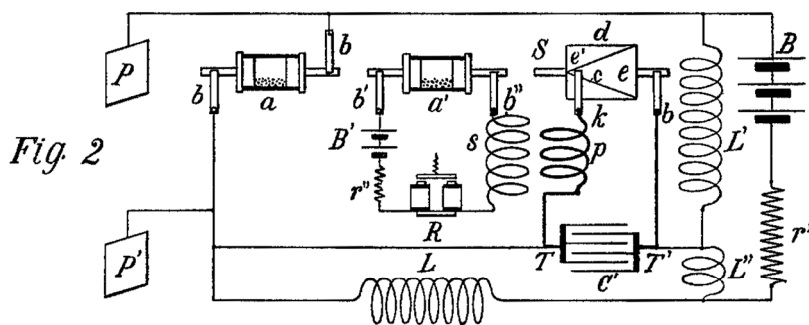
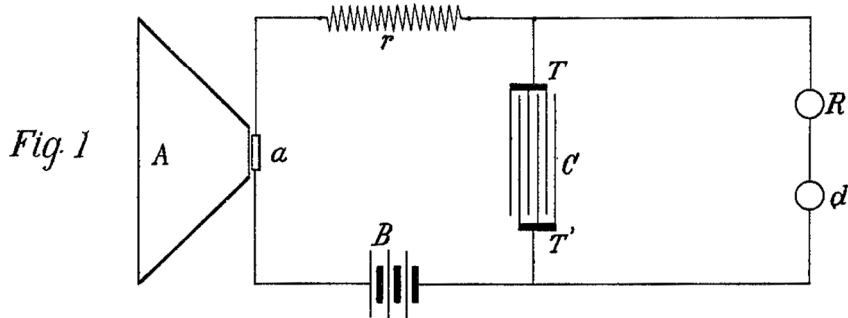
E.A. 森德林、D. D.洛德。

N. TESLA.

APPARATUS FOR UTILIZING EFFECTS TRANSMITTED THROUGH NATURAL MEDIA.

(Application filed Nov. 2, 1899. Renewed May 29, 1901.)

(No Model.)



Witnesses:

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METHOD OF SIGNALING

发送信号的方法

NIKOLA TESLA, OF NEW YORK, N. Y.

纽约州纽约市的尼古拉·特斯拉

SPECIFICATION forming part of Letters Patent No. 723,188, dated March 17, 1903.

Original application filed July 16, 1900, Serial No. 23,847. Divided and this application filed June 14, 1901. Serial No. 64,522. (No model.)

该说明书形成了颁发于 1903 年 3 月 17 日编号为 723,188 的专利证书的一部分。
原始申请于 1900 年 7 月 16 日提交，序列号为 23,847。在 1901 年 6 月 14 日原始申请被分立并且提交了该申请。序列号 64522。(无模型。)

To all whom it may concern:

致所有相关人士:

Be it known that I, NIKOLA TESLA, a citizen of the United States, residing in the borough of Manhattan, in the city, county, and State of New York, have invented certain new and useful Improvements in Methods of Signaling, of which the following is a specification, reference being had to the drawings accompanying and forming a part of the same.

众所周知，我，尼古拉特斯拉，一名美国公民，居住在纽约州纽约郡纽约市的曼哈顿区，在发送信号的方法上已经发明了某些新的和有用的改进，以下是该发明一个说明书，必须参考随附的图纸，它已形成该说明书的一部分。

In certain systems for transmitting intelligible messages or governing the movements and operations of distant automata electrical impulses or disturbances produced by suitable apparatus are conveyed through the natural media to a receiving-circuit capable of responding to the impulses, and thereby effecting the control of other appliances. Generally a special device, highly sensitive, is connected to the receiving-circuit, which in order to render it still more susceptible and to reduce the liability of its being affected by extraneous disturbances is carefully adjusted so as to be in tune with the transmitter. By a scientific design of the sending and receiving circuits and other apparatus and skillful adjustment of the same these objects may be in a measure attained; but in long experience I have found that notwithstanding all constructive advantages and experimental resources this method is in many cases inadequate. Thus while I have succeeded in so operating selectively under certain favorable conditions more than one hundred receivers in most cases it is practicable to work successfully but a few, the number rapidly diminishing as, either owing to great distance or other causes, the energy available in the tuned circuits becomes smaller and the receivers necessarily more delicate. Evidently a circuit however well constructed and adjusted to respond exclusively to vibrations of one period is apt to be affected by higher harmonics and still more so by lower ones. When the oscillations are of a very high frequency, the number of the effective harmonics may be large and the receiver consequently easily

disturbed by extraneous influences to such an extent that when very short waves, such as those produced by Hertzian spark apparatus, are used little advantage in this respect is to be derived from tuning the circuits. It being an imperative requirement in most practical applications of such systems of signaling or intelligence transmission that the signals or messages should be exclusive or private, it is highly desirable to do away with the above limitations, especially in view of the fact which I have observed that the influence of powerful electrical disturbances upon sensitive receivers extends even on land to distances of many hundreds of miles, and consequently, in accordance with theory, still farther on sea. To overcome these drawbacks and to enable a great number of transmitting and receiving stations to be operated selectively and exclusively and without any danger of the signals or messages being disturbed, intercepted, or interfered with in any way is the object of my present invention.

在某些用于传输可理解的信息或控制远程自动装置的运动和操作的系统中,由合适的设备产生的电脉冲或扰动通过自然媒介被传送到一个接收电路,该接收电路能够响应脉冲,从而影响其他设备的控制。通常,一个高灵敏度的特殊装置被连接到接收电路,为了使该电路更易影响并降低该电路受外界干扰导致的不利因素,该接收电路被仔细地与发射器同步。通过发送电路的和接收电路的以及其他设备的科学设计,还有熟练的调整,这些目的可以在一定程度上实现,但尽管拥有所有的建设性优势和实验资源,这种方法在许多情况下是不充分的。因此,虽然在某些有利的条件下,有选择地操作一百多个接收器是可行的,但在大多数情况下,能有可能成功地工作的只有少数几个,由于距离远或其他原因,能成功地工作的接收器数量迅速减少,同步电路中可用的能量变得更小,因此接收器必然更精密。显然,一个电路,无论如何出色地构建和调整,以排外地响应一种周期的振动,都容易受到高次谐波的影响,尤其是受到基音的影响。当振荡频率很高时,有效谐波的数量可能很大,因此接收器很容易受到外来影响的干扰,以至于当采用非常短的波,如赫兹火花装置产生的波时,从调谐电路中不会得到什么好处。在这种信号或情报的传输系统的大多数实际应用中,信号或消息应该是专有的或私有的,这是一个迫切的要求,因此,非常希望消除上述限制,更重要的是,因为这是一个事实,强大的电干扰对敏感接收器的影响甚至在陆地上延伸到数百英里的距离,因此,根据理论,在海上这种影响会延伸得更远。为了克服这些缺点,并使大量的发射站和接收站有选择地和排外地工作,而没有任何信号或消息被干扰或截获或以任何方式被妨碍的危险,这是我的目前发明的目的。

Broadly stated, this invention consists in generating two or more kinds or classes of disturbances or impulses of distinctive character with respect to their effect upon a receiving-circuit and operating thereby a distant receiver which comprises two or more circuits, each of which is tuned to respond exclusively to the disturbances or impulses of one kind or class and so arranged that the operation of the receiver is dependent upon their conjoint or resultant action.

概括地说,本发明包括产生两种或多种类型或种类的扰动或脉冲,这些扰动或脉冲能作用于一个接收电路并操作一个远处的接收器,该接收器由两个或多个电路组成,每个电路被调谐成排外地响应一种类型或种类的扰动或脉冲,并被设置成接收器的操作要依赖于这些电路的联合或合成作用。

By employing only two kinds of disturbances or series of impulses instead of one, as has heretofore been done, to operate a receiver of this kind I have found that safety against the disturbing influences of other sources is increased to such an extent that I believe this number to be amply sufficient in most cases for rendering the exchange of signals or messages reliable and exclusive; but in exceptional

instances a greater number may be used and a degree of safety against mutual extraneous interference attained, such as is comparable to that afforded by a combination-lock. The liability of a receiver being affected by disturbances emanating from other sources, as well as that of the signals or messages being received by instruments for which they are not intended, may, however, be reduced not only by an increased number of the cooperative disturbances or series of impulses, but also by judicious choice of the same and order in which they are made to act upon the receiver.

通过仅使用两种扰动或两个序列的脉冲而不是一种,正如迄今为止操作这种类型的接收器所做的那样,我发现对其他源的干扰影响的安全性增加到这样的程度,即我相信这个数目在大多数情况下足以使信号或消息的交换变得可靠和排他;但是在特殊情况下,可以使用更大的数量,并且获得一定程度的防止相互干扰和外来干扰的安全性,这样就可以与密码锁相比。然而,接收器受来自其它源的干扰影响的可能性,以及信号或信息被仪器接收到的可能性,不仅可以通过增加协同干扰或脉冲序列的数量来降低,而且可以通过明智地选择扰动或脉冲以及它们作用于接收器的顺序来降低。

Evidently there are a great many ways of generating impulses or disturbances of any wave length, wave form, number or order of succession, or of any special character, such as will be capable of fulfilling the requirements above stated, and there are also many ways in which such impulses or disturbances may be made to cooperate and to cause the receiver to be actuated, and inasmuch as the skill and practical knowledge in these novel fields can only be acquired by long experience the degree of safety and perfection attained will necessarily depend upon the ability and resource of the expert who applies my invention; but in order to enable the same to be successfully practiced by any person possessed only of the more general knowledge and experience in these branches I shall describe the simplest plan of carrying it out which is at present known to me.

显然,有很多种方法可以产生能够满足上述要求的任何波长、波形、数量或者任何连续顺序的、或者任何期望的特殊特性的脉冲或扰动,并且也有许多方法可以使这种脉冲或扰动协同工作并使接收器启动,因为这些新领域的技能和实践知识只能通过长期的经验获得,所达到的安全和完善的程度将必然取决于应用我的发明的专家的能力和资源,但为了使任何仅具有这些分支的一般知识和经验的人能够成功地实践同样的方法,我将描述执行它的最简单的方案,这是目前我所知道的。

For a better understanding of the subject reference is now made to the accompanying drawings, in which—

为了更好地理解主题,现在参考附图,其中—

Figures 1 and 2 represent diagrammatically an apparatus and circuit connections employed at the sending and receiving stations, respectively, for the practice of my invention; and Figs. 3, 4, and 5, modified means which may be employed in the practical application of the invention. In Fig. 1, S^1 and S^2 are two spirally-wound coils or conductors connected with their inner ends to preferably elevated terminals D^1 and D^2 , respectively, and with their outer ends to an earth-plate E. These two coils, conductors, or systems $D^1 S^1 E$ and $D^2 S^2 E$ have different and suitably-chosen periods of vibration, and, as pointed out in other patents relating to my system of energy and intelligence transmission, their lengths should be such that the points of maximum pressure developed therein coincide with the

elevated terminals $D^1 D^2$. By suitable-chosen periods of vibration such periods are meant as will secure the greatest safety against interference, both mutual and extraneous. The two systems may have electrical oscillations impressed upon them in any desired manner conveniently by energizing them through primaries P^1 and P^2 , placed in proximity to them. Adjustable inductances L^1 and L^2 are preferably included in the primary circuits chiefly for the purpose of regulating the rates of the primary oscillations. In the drawings these primaries P^1 and P^2 surround the coils $S^1 S^2$ and are joined in series through the inductances $L^1 L^2$, conductor F , condensers C^1 and C^2 , brush-holders B^1 and B^2 , and a toothed disk D , which is connected to the conductor F and, if desired, also to the ground-plate E , as shown, two independent primary circuits being thus formed. The condensers C^1 and C^2 are of such capacity and the inductances L^1 and L^2 are so adjusted that each primary is in close resonance with its secondary system, as I have explained in other patents granted to me. The brush holders B^1 and B^2 are capable independently of angular and, if necessary, also of lateral adjustment, so that any desired order of succession or any difference of time interval between the discharges occurring in the two primary circuits may be obtained. The condensers being energized from a suitable source S , preferably of high potential, and the disk D being rotated, its projections or teeth $p p$ coming at periodically-recurring intervals in very close proximity to or, as the case may be, in contact with conducting rods or brushes $n n$ cause the condensers to be discharged in rapid succession through their respective circuits. In this manner the two secondary systems $D^1 S^2 E$ and $D^2 S^1 E$ are set in vibration and oscillate freely each at its proper rate for a certain period of time at every discharge. The two vibrations are impressed upon the ground through the plate E and spread to a distance reaching the receiving-station, which has two similar circuits or systems $e^1 s^1 d^1$ and $e^2 s^2 d^2$, arranged and connected in the same manner and tuned to the systems at the sending-station, so that each responds exclusively to one of the two vibrations produced by the transmitting apparatus. The same rules of adjustment are observed with respect to the receiving-circuits, care being furthermore taken that the tuning is effected when all the apparatus is connected to the circuits and placed in position, as any change may more or less modify the vibration. Each of the receiving-coils s^1 and s^2 is shunted by a local circuit containing, respectively, sensitive devices $a^1 a^2$, batteries $b^1 b^2$, adjustable resistances $r^1 r^2$, and sensitive relays $R^1 R^2$, all joined in series, as shown. The precise connections and arrangements of the various receiving instruments are largely immaterial and may be varied in many ways. The sensitive devices $a^1 a^2$ may be any of the well-known devices of this kind—as, for example, two conducting-terminals separated by a minute air-gap or a thin film of dielectric which is strained or weakened by a battery or other means to the point of breaking down and gives way to the slightest disturbing influence. Its return to the normal sensitive state may be secured by momentarily interrupting the battery-circuits after each operation or otherwise. The relays $R^1 R^2$ have armatures $l^1 l^2$, which are connected by a wire w and when attracted establish electrical contacts c^1 and c^2 , thus closing a circuit containing a battery b^3 and adjustable resistance r^3 and a relay R^3 . From the above description it will be readily seen that the relay R^3 will be operated only when both contacts c^1 and c^2 are closed.

图 1 和 2 分别示意性地表示了用于我的发明实践的发送站和接收站所采用的一个设备和多个电路连接；图 3、4 和 5 展示了可用于本发明实际应用的改进后的工具。在图 1 中， S^1 和 S^2 是两个螺旋缠绕的线圈或导体，它们的内部端最好分别连接到高架终端 D^1 和 D^2 ，它们的外端连接到接地板 E 。这两个线圈、导体、或系统 $D^1 S^1 E$ 和 $D^2 S^2 E$ 有不同的和适当选择的振动周期，正如在其他关于我的能量和情报传输系统的专利中指出的，它们的长度应该是最大压力点与高架终端 $D^1 D^2$ 一致。通过适当选择振动周期，这种周期意味着将最大程度地防止相互干扰和外来干扰。这两个系统可以通过放置在它们附近的初级线圈 P^1 和 P^2 来激励，

从而以任何期望的方式方便地施加电振荡。可调电感 L^1 和 L^2 最好被包含在初级电路中，主要是为了调节初级振荡的速率。在附图中，这些初级线圈 P^1 和 P^2 围绕线圈 $S^1 S^2$ ，并通过电感 $L^1 L^2$ 、导体 F 、电容器 C^1 和 C^2 、电刷架 B^1 和 B^2 以及齿盘 D 串联连接，齿盘 D 连接到导体 F ，如果需要，还连接到接地板 E ，如图所示，这样就形成了两个独立的初级电路。 C^1 和 C^2 的电容器容量如此之大， L^1 和 L^2 的电感如此调整，以至于每个初级系统都与其次级系统紧密谐振，正如我在授予我的其他专利中所解释的那样。电刷架 B^1 和 B^2 能够独立地进行角度调节，并且如果需要的话，还能够进行横向调节，从而可以获得在两个初级电路中发生的放电之间的任何期望的承继顺序或任何时间间隔差异。电容器由一个合适的电源 S (最好是高电位电源) 供电，圆盘 D 旋转，其突起或齿 $p p$ 在周期性重复的时间间隔内与导电杆或电刷 $n n$ 非常靠近或视情况而定进行接触，使电容器通过它们各自的电路快速连续地放电。这样，两个次级系统 $D^1 S^2 E$ 和 $D^2 S^1 E$ 被置于振动状态，并在每次放电的一定时间内以各自适当的速率自由振荡。这两个振动通过板 E 施加在地面上，并传播到一定距离到达接收站，该接收站具有两个类似的电路或系统 $e s^1 d^1$ 和 $e s^2 d^2$ ，它们以相同的方式布置和连接，并调谐到发送站的系统，使得每个都排外地响应由发送装置产生的两个振动之一。对于接收电路，观察到相同的调整规则，此外要注意的是，当所有设备都连接到电路并放置到位时，调谐才有效，因为任何变化都可以或多或少地改变振动。接收线圈 s^1 和 s^2 中的每一个都被一个局部电路分流，该局部电路分别包含敏感设备 $a^1 a^2$ 、电池 $b^1 b^2$ 、可调电阻 $r^1 r^2$ 和敏感继电器 $R^1 R^2$ ，如图所示，所有这些都串联在一起。各种接收仪器的精确连接和布置在很大程度上是不重要的，并且可以以多种方式变化。敏感装置 $a^1 a^2$ 可以是这种类型的任何众所周知的装置——例如，由微小的空气间隙或电介质薄膜分隔的两个导电终端，空气间隙或电介质薄膜被电池或其他工具应变或削弱到击穿的程度，并让路于最轻微的扰动影响。可以通过在每次操作后或其他情况下暂时中断电池电路来确保它恢复到正常的敏感状态。继电器 $R^1 R^2$ 带有衔铁 $l^1 l^2$ ，它们通过一根导线 w 连接，当衔铁被吸引时建立电触点 c^1 和 c^2 ，从而闭合一个包含电池 b^3 、可调电阻 r^3 和继电器 R^3 的电路。从上面的描述中很容易看出，继电器 R^3 只有在触点 c^1 和 c^2 都闭合时才会工作。

The apparatus at the sending-station may be controlled in any suitable manner—as, for instance, by momentarily closing the circuit of the source S , two different electric vibrations being emitted simultaneously or in rapid succession, as may be desired, at each closure of the circuit. The two receiving-circuits at the distant station, each tuned to respond to the vibrations produced by one of the elements of the transmitter, affect the sensitive devices a^1 and a^2 and cause the relays R^1 and R^2 to be operated and contacts c^1 and c^2 to be closed, thus actuating the receiver or relay R^3 , which in turn establishes a contact c^3 and brings into action a device a^3 by means of a battery b^4 , included in a local circuit, as shown. But evidently if through any extraneous disturbance only one of the circuits at the receiving-station is affected the relay R^3 will fail to respond. In this way a communication may be carried on with greatly-increased safety against interference and privacy of the messages may be secured. The receiving-station shown in Fig. 2 is supposed to be one requiring no return message; but if the use of the system is such that this is necessary then the two stations will be similarly equipped, and any well-known means, which it is not thought necessary to illustrate here, may be resorted to for enabling the apparatus at each station to be used in turn as transmitter and receiver. In like manner the operation of a receiver, as R^3 , may be made dependent instead of upon two upon more than two such transmitting systems or circuits, and thus any desired degree of exclusiveness or privacy and safety against extraneous disturbances may be attained. The apparatus as illustrated in Figs. 1 and 2 permits, however, special results to be secured by the adjustment of the order of succession of the discharges of the primary circuits P^1 and P^2 or of the time interval between such discharges. To illustrate: The action of the relays

$R^1 R^2$ may be regulated either by adjusting the weights of the levers $l^1 l^2$, or the strength of the batteries $b^1 b^2$ or the resistances $r^1 r^2$, or in other well-known ways, so that when a certain order of succession or time interval between the discharges of the primary circuits P^1 and P^2 exists at the sending-station the levers l^1 and l^2 will close the contacts c^1 and c^2 at the same instant, and thus operate the relay R^3 , but will fail to produce this result when the order of succession or the time interval between the discharges in the primary circuits is another one. By these or similar means additional safety against disturbances from other sources may be attained and, on the other hand, the possibility afforded of effecting the operation of signaling by varying the order of succession of the discharges of the two circuits. Instead of closing and opening the circuit of the source S^1 , as before indicated, for the purpose of sending distinct signals it may be convenient to merely alter the period of either of the transmitting-circuits arbitrarily, as by varying the inductance of the primaries.

发送站处的设备可以以任何合适的方式控制，例如，通过瞬时闭合电源 S 的电路，在每次闭合电路时，根据需要，同时或快速连续地发射两种不同的电振动。在远处站点的两个接收电路，每个都被调谐以响应由发射器的组件中的一个所产生的振动，影响敏感装置 a^1 和 a^2 ，并使继电器 R^1 和 R^2 工作，也使触点 c^1 和 c^2 闭合，从而启动接收器或继电器 R^3 ，这反过来又建立了触点 c^3 ，并通过包括在局部电路中的电池 b^4 使装置 a^3 工作，如图所示。但是很明显，如果由于任何外来干扰，只有接收站的一个电路受到影响，继电器 R^3 将不能响应。以这种方式，通信可以在大大增强的抗干扰的安全性下进行，并且可以保护消息的隐私。假设图 2 所示的接收站不需要返回消息；如果系统的使用是必要的，那么两个站将被类似地装备，并且可以采用任何众所周知的装置，以使每个站的设备轮流被用作发射机和接收机，这些装置被认为没有必要在此展示。以类似的方式，如 R^3 的一个接收机的操作可以依赖于多于两个这样的发射系统或电路，而不是依赖于两个发射系统或电路，因此可以获得任何期望程度的排他性或私密性以及对抗外来干扰的安全性。然而，图 1 和图 2 所示的装置允许通过调节初级回路 P^1 和 P^2 的连续放电顺序或这种放电之间的时间间隔来获得特殊的结果。参考附图来说明：继电器 $R^1 R^2$ 的作用可以通过调节杠杆 $l^1 l^2$ 的重量，或者电池 $b^1 b^2$ 的强度，或者电阻 $R^1 R^2$ ，或者以其他众所周知的方式来调节，使得当在发送站的初级电路 P^1 和 P^2 的放电之间存在的一定承继顺序或时间间隔时，杠杆 $l^1 l^2$ 将同时闭合触点 c^1 和 c^2 ，从而操作继电器 R^3 ，但是当初级电路中放电的连续顺序或时间间隔是另一种时，将不能产生这个结果。通过这些或类似的手段，可以获得额外的安全性，防止来自其他来源的干扰，另一方面，通过改变两个电路的放电的承继顺序，提供了实现信号操作的可能性。如前所述，为了发送不同的信号，仅仅通过改变初级线圈的电感来任意改变任一发射电路的周期会是方便的，而不是闭合和断开电源 S^1 的电路。

Obviously there is no necessity for using transmitters with two or more distinct elements or circuits, as S^1 and S^2 , since a succession of waves or impulses of different characteristics may be produced by an instrument having but one such circuit. A few of the many ways which will readily suggest themselves to the expert who applies my invention are illustrated in Figs. 3, 4, and 5. In Fig. 3 a transmitting system $e^3 d^3$ is partly shunted by a rotating wheel or disk D^3 , which may be similar to that illustrated in Fig. 1 and which cuts out periodically a portion of the coil or conductor s^3 or, if desired, bridges it by an adjustable condenser C^3 , thus altering the vibration of the system $e^3 d^3$ at suitable intervals and causing two distinct kinds or classes of impulses to be emitted in rapid succession by the sender. In Fig. 4 a similar result is produced in the system $e^4 d^4$ by periodically short-circuiting, through an induction-coil L^3 and a rotating disk D^4 with insulating and conducting segments, a circuit p^4 in inductive relation to said system. Again, in Fig. 5 three distinct vibrations are caused to be emitted by a system $e^5 d^5$, this

result being produced by inserting periodically a number of turns of an induction-coil L^4 in series with the oscillating system by means of a rotating disk B^5 with two projections $p^5 p^5$ and three rods or brushes n^5 , placed at an angle of one hundred and twenty degrees relatively to each other. The three transmitting systems or circuits thus produced may be energized in the same manner as those of Fig. 1 or in any other convenient way. Corresponding to each of these cases the receiving-station may be provided with two or three circuits in an analogous manner to that illustrated in Fig. 2, it being understood, of course, that the different vibrations or disturbances emitted by the sender follow in such rapid succession upon each other that they are practically simultaneous so far as the operation of such relays as R^1 and R^2 is concerned. Evidently, however, it is not necessary to employ two or more receiving-circuits, but a single circuit may be used also at the receiving-station constructed and arranged like the transmitting-circuits or systems illustrated in Figs. 3, 4, and 5, in which case the corresponding disks, as $D^3 D^4 D^5$, at the sending will be driven in synchronism with those at the receiving stations as far as may be necessary to secure the desired result; but whatever the nature of the specific devices employed it will be seen that the fundamental idea in my invention is the operation of a receiver by the conjoint or resultant effect of two or more circuits each tuned to respond exclusively to waves, impulses, or vibrations of a certain kind or class produced either simultaneously or successively by a suitable transmitter.

显然，没有必要使用具有两个或更多不同组件或电路的发射机，如 S^1 和 S^2 ，因为一个仪器只有一个这样的电路就可以产生一系列不同特性的波或脉冲。图 3、4 和 5 展示了应用我的发明的专家容易想到的许多方法中的一些。在图 3 中，发射系统 $e s^3 d^3$ 被一个旋转的轮或盘 d^3 部分分流，该轮或盘 d^3 可以类似于图 1 中所示的轮或盘 D^3 ，并且周期性地排除线圈或导体 s^3 的一部分，或者如果需要，通过可调节的电容器 C^3 将其桥接，从而以适当的时间间隔改变系统 $e s^3 d^3$ 的振动，并且使得发送器快速连续地发射两种不同种类或类别的脉冲。在图 4 中，通过感应线圈 L^3 和具有绝缘和导电部分的旋转圆盘 D^4 周期性地短路与所述系统成感应关系的电路 p^4 ，在系统 $e s^4 d^4$ 中产生类似的结果。同样，在图 5 中，由系统 $e s^5 d^5$ 导致的三种不同的振动，这一结果是通过借助于旋转盘 B^5 周期性地插入与振动系统串联的感应线圈 L^4 的一些匝数而产生的，该旋转盘 B^5 具有两个突出物 $p^5 p^5$ 和三个杆或刷 n^5 ，它们相对于彼此以 120 度的角度放置。如此产生的三个发射系统或电路可以以与图 1 相同的方式或以任何其他方便的方式被激励。对应于这些情况中的每一种，接收站可以以类似于图 2 所示的方式装备有两个或三个电路，当然，可以理解，由发送器发出的不同振动或扰动以如此快地连续不断地出现，就 R^1 和 R^2 这样的继电器的操作而言，以至于它们实际上是同时发生的。然而，显然没有必要采用两个或更多的接收电路，但是在接收站也可以使用单个电路，其结构和布置类似于图 3、4 和 5 中所示的发射电路或系统，在这种情况下，在发送端的相应转盘，如 $D^3 D^4 D^5$ ，将与接收站的那些转盘同步驱动，以保证所需的结果；但是不管所采用的具体设备的性质如何，可以看出，本发明的基本思想是通过两个或多个电路的联合或合成效应来操作接收器，每个电路都被调谐成排外地响应由一个合适的发射器同时或相继产生的特定种类或类别的波、脉冲或振动。

It will be seen from a consideration of the nature of the method hereinbefore described that the invention is applicable not only in the special manner described, in which the transmission of the impulses is effected through natural media, but for the transmission of energy for any purpose and whatever the medium through which the impulses are conveyed.

从上文所述方法的性质可以看出，本发明不仅适用于所述的通过自然媒介实现脉冲传输的特殊方式，而且适用于任何目的的能量传输，无论脉冲通过何种媒介传送。

What I claim is—

我主张的是—

1. The method of operating distant receivers which consists in producing and transmitting a plurality of kinds or classes of electrical impulses or disturbances, actuating by the impulses or disturbances of each kind or class one of a plurality of circuits tuned to respond to impulses of such kind or class and operating or controlling the operation of a receiver by the conjoint action of two or more of said circuits, as set forth.

1、操作远程接收器的方法，包括产生和发送多个种类或类别的电脉冲或扰动，通过每个种类或类别的脉冲或扰动来启动多个电路中的一个电路，这些电路被调谐以响应这些种类或类别的脉冲，并通过两个或多个所述电路的联合作用来操作或控制一个接收器的操作，如上所述。

2. The method of signaling, which consists in producing and transmitting a plurality of kinds or classes of electrical impulses or disturbances, developing by the impulses of each class a current in one of a plurality of receiving-circuits tuned to respond exclusively thereto and controlling by means of the conjoint action of such circuits a local-circuit, as set forth.

2、一种发送信号的方法，包括产生和发送多个种类或类别的电脉冲或扰动，通过每类脉冲在多个接收电路中的一个电路产生电流，这些电路被调谐成排他性地响应该电流，并通过这些电路的联合作用来控制一个局部电路，如前所述。

3. The method of signaling which consists in producing a plurality of series of impulses or disturbances differing from each other in character and order of succession, exciting by the impulses of each series one of a plurality of receiving-circuits tuned to respond exclusively thereto and controlling by the conjoint action of such circuits a local-circuit, as set forth.

3、一种发送信号的方法，包括产生多个在性质和承继顺序上互不相同的脉冲或扰动序列，由每个序列的脉冲激励多个接收电路中的一个，该接收电路被调谐成对该脉冲做出排他性响应，并通过这些电路的联合作用来控制一个本地电路，如前所述。

4. The method of signaling which consists in producing a plurality of series of electrical impulses of different character, varying the time interval between the emission of such impulses, exciting by the impulses of each series one of a plurality of receiving-circuits tuned to respond exclusively thereto and controlling by the conjoint action of such circuits a local circuit, as set forth.

4、一种发送信号的方法，包括产生多个不同特性的电脉冲序列，改变这些脉冲发射之间的时间间隔，由每个序列的脉冲激励多个接收电路中的一个，这些接收电路被调谐成排他地对其做出响应，并通过这些电路的联合作用来控制一个局部电路，如前所述。

5. The method of transmitting electrical energy for conveying intelligible signals which consists in producing a plurality of electrical impulses of different character, developing by the impulses of each kind a current in one of a plurality of receiving-circuits tuned to respond exclusively thereto, controlling

the action or effect of the transmitted impulses upon the receiving-circuits by varying the character of said impulses, and operating or controlling the operation of a receiver by the conjoint action of two or more of said receiving-circuits, as set forth.

5、用来传输传送可理解信号的传输电能的方法，包括产生多个不同特性的电脉冲，通过每种类型的脉冲在多个接收电路中的一个中产生电流，这些接收电路被调谐以排他地对这些电流进行响应，通过改变所述脉冲的特性来控制所传输的脉冲在接收电路上的作用或效果，以及通过两个或多个所述接收电路的联合作用来操作或控制一个接收器，如上所述。

6. The method of transmitting electrical energy which consists in producing a plurality of electrical waves or impulses of different periodicities, varying the order of transmission of the waves or impulses forming elements of the signal sent, according as one or another receiving-station is to be communicated with where (proper circuit-closing mechanism being provided at each receiving-station) the transmitted signal will be intelligible at and only at the intended receiving-station.

6、一种传输电能的方法，它包括产生多个不同周期的电波或脉冲，改变构成发送信号元素的电波或脉冲的传输顺序，这是根据一个或另一个接收站要与哪个接收站通信(在每个接收站提供适当的电路闭合机制)，所传输的信号只有在预定的接收站才是可理解的。

7. The method of transmitting intelligence, which consists in selecting and associating together in predetermined order of succession two or more electrically-generated impulses of different periodicity, forming elements of signals to be sent, and transmitting such selected impulses with reference to the conjoint action of both or all in the production of a signal at a distant point, substantially as set forth.

7、一种传输信息的方法，包括选择两个或多个不同周期的电产生的脉冲，并以预定的连续顺序将它们联系在一起，形成要发送的信号元素，并根据两者或全部在远处产生信号的联合作用来传输这样选择的脉冲。

8. In a system of telegraphy, wherein signals or messages are sent by the use of a plurality of electrical impulses of different periodicities and in a predetermined order of succession, the method of ascertaining at any particular station the particular signal sent to that station, which consists in the selection, to form a signal, of certain transmitted impulses of different periodicities and of a predetermined order of succession to the exclusion of all others, as set forth.

8、在一个电报系统中，信号或信息是通过使用多个不同周期的电脉冲并按预定的承继顺序发送的，在任何特定的站确定发送到该站的特定信号的方法，包括选择不同周期的和预定承继顺序的某些被发送的脉冲以形成一个信号，来排除所有其它的信号，如上所述。

9. The improvement in the art of transmitting electrical energy which consists in operating or controlling a receiving mechanism by a series or group of electrical impulses of different periodicities and of a predetermined order of succession.

9、电能传输技术的改进，包括通过一系列或一组不同周期和预定承继顺序的电脉冲来操作或控制接收装置。

10. In a system for the transmission of electrical energy, for sending signals or messages to any one of two or more receiving-stations, the method of transmitting the message with reference to the intelligible receipt thereof at the desired station, which consists in the transmission of electrical waves or impulses of different periodicities in varying order of transmittal by a separate order or grouping of transmittal for each receiving-station.

10、在一个电能传输系统中，为了向两个或多个接收站中的任何一个发送信号或信息，发射信息的方法是关于在所需站的情报接受，该方法包括通过用于每个接收站的一个单独的传输顺序或传输分组以不同的传输顺序传输不同周期的电波或脉冲。

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N. TESLA.

METHOD OF SIGNALING.

APPLICATION FILED JUNE 14, 1901.

NO MODEL

Fig. 2

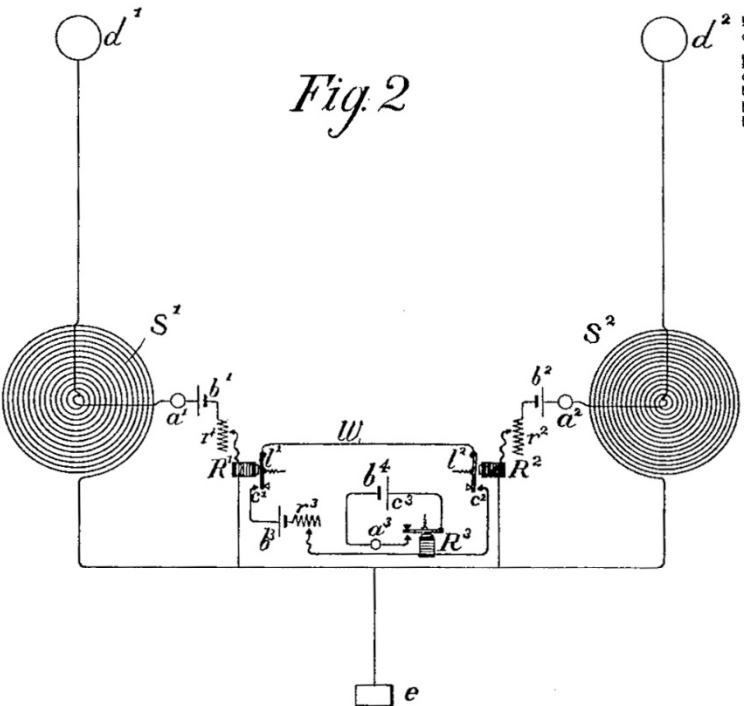


Fig. 5

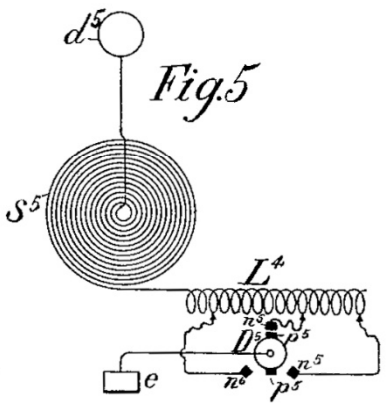


Fig. 4

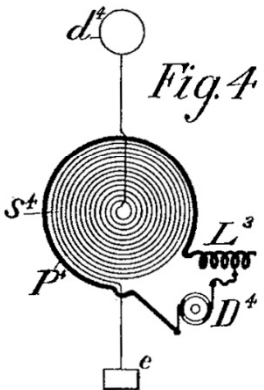


Fig. 1

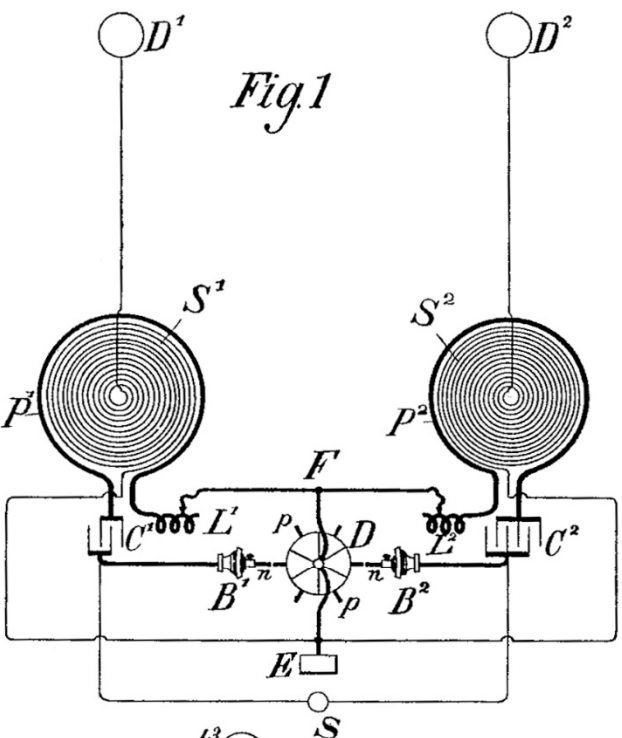
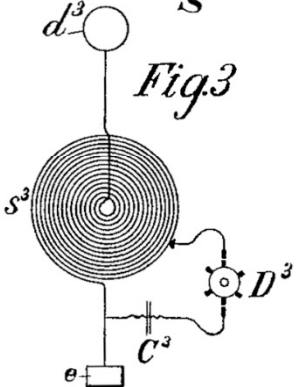


Fig. 3



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Improvements in and Relating to the Transmission of Electrical Energy

电能传输中的和与电能传输相关的改进

No 14,579 A.D. 1901
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COMPLETE SPECIFICATION.
完整说明

Communicated from abroad by Nikola Tesla, of 46 East Houston Street, Borough of Manhattan,
City, County and State of New York, United States of America, Electrician.
居住在美国纽约州纽约郡纽约市曼哈顿区东休斯顿街 46 号的
电气技师尼古拉·特斯拉发来的通讯。

I, Henry Harris Lake, of the Firm of Haseltine, Lake & Co., Patent Agents, 45 Southampton Buildings,
in the County of Middlesex, do hereby declare the nature of this invention and in what manner the
same is to be performed, to be particularly described and ascertained in and by the following statement:

我，亨利·哈里斯·雷克，来自英国密得塞斯郡南安普顿大厦 45 号哈兹尔廷（雷克）专利
代理公司，特此声明本发明的性质以及以何种方式执行本发明，并在以下声明中具体说明和
确定：

In certain systems for transmitting intelligible messages, or governing the movements and operations
of distant automata, electrical impulses or disturbances, produced by suitable apparatus, are conveyed
through the natural media to a receiving circuit, capable of responding to the impulses and thereby
effecting the control of other appliances. Generally a special device, highly sensitive, is connected to
the receiving circuit which, in order to render it still more susceptible and to reduce the liability of its
being affected by extraneous disturbances, is carefully synchronized with the transmitter. By a scientific
design of the sending and receiving circuits and other apparatus, and skillful adjustment of the same,
these objects may be in a measure attained, but notwithstanding all constructive advantages and
experimental resources, this method is in many cases inadequate. Thus, while it is practicable to operate,
selectively, under certain favorable conditions, more than one hundred receivers, in most cases it is
possible to work successfully but a few, the number rapidly diminishing as, either owing to great
distance or other causes, the energy available in the synchronized circuits becomes smaller, and
therefore the receivers necessarily more delicate. Evidently a circuit, however excellently constructed
and adjusted to respond exclusively to vibrations of one period, is apt to be affected by higher
harmonics, and still more so by fundamental tones. When the oscillations are of a very high frequency,

the number of the effective harmonics may be large, and the receiver is consequently easily disturbed by extraneous influences, to such an extent that, when very short waves, as those produced by Hertzian spark apparatus, are employed, little benefit in this respect is derived from synchronizing the circuits. It being an imperative requirement in most practical applications of such systems of signaling or intelligence transmission, that the signals or messages should be exclusive or private, it is highly desirable to do away with the above limitations, all the more so, as it is a fact, that the influence of powerful electrical disturbances upon sensitive receivers extends, even on land, to distances of many hundreds of miles and consequently, in accordance with theory, still farther on sea.

在某些用于传输可理解的信息或控制远程自动装置的运动和操作的系统中,由合适的设备产生的电脉冲或扰动通过自然媒介被传送到一个接收电路,该接收电路能够响应脉冲,从而影响其他设备的控制。通常,一个高灵敏度的特殊装置被连接到接收电路,为了使该电路更易受影响并降低该电路受外界干扰导致的不利因素,该接收电路被仔细地与发射器同步。通过发送电路和接收电路的以及其他设备的科学设计,还有熟练的调整,这些目的可以在一定程度上实现,但尽管拥有所有的建设性优势和实验资源,这种方法在许多情况下是不充分的。因此,虽然在某些有利的条件下,有选择地操作一百多个接收器是可行的,但在大多数情况下,有可能成功地工作的只有少数几个,由于距离远或其他原因,能成功地工作的接收器的数量迅速减少,同步电路中可用的能量变得更小,因此接收器必然更精密。显然,一个电路,无论如何出色地构建和调整,以排他地响应一种周期的振动,都容易受到高次谐波的影响,尤其是受到基音的影响。当振荡频率很高时,有效谐波的数量可能很大,因此接收器很容易受到外来影响的干扰,以至于当采用非常短的波,如赫兹火花装置产生的波时,从调谐电路中得不到什么好处。在这种信号或情报的传输系统的大多数实际应用中,信号或消息应该是专有的或私密的,这是一个迫切的要求,因此,非常希望消除上述限制,更重要的是,因为这是一个事实,强大的电干扰对敏感接收器的影响甚至在陆地上延伸到数百英里的距离,因此,根据理论,在海上这种影响会延伸得更远。

To overcome these drawbacks and to enable a great number of transmitting and receiving stations to be operated, selectively and exclusively, and without any danger of the signals or messages being disturbed or intercepted, or interfered with in any way, is the object of my present improvement.

为了克服这些缺点,并使大量的发射站和接收站有选择地和排他地工作,而没有任何信号或消息被干扰或截获或以任何方式被妨碍的危险,这是我的目前改进的目的。

Broadly stated, my invention involves the employment of means for generating two or more kinds or classes of disturbances, waves or impulses of distinctive character, with respect to their effect upon a receiving apparatus, and a distant receiver, which comprises two or more elements, severally responsive to the different disturbances or impulses, and which is dependent for operation upon the conjoint or resultant action of two or more such elements.

总的来说,我的发明包括产生两种或多种不同特征的扰动、波或脉冲的工具,关于这些扰动、波或脉冲对一个接收设备和远处接收器的影响,这些设备和接收器包括两个或多个组件,分别响应不同的扰动或脉冲,并且依赖两个或多个这样的组件的联合作用或合成作用来操作。

By employing only two kinds of disturbances or impulses instead of one, as has heretofore been done, to operate a receiver, safety against the disturbing influences of other sources is increased to such an

extent, that this number is probably amply sufficient in most cases for rendering the exchange of signals or messages reliable and exclusive, but in exceptional instances a greater number may be used, and a degree of safety against mutual and extraneous interference attained, such as is comparable to that afforded by a combination lock.

通过仅使用两种扰动或脉冲而不是像迄今为止所做的那样使用一种扰动或脉冲来操作接收器,抵抗其他源的干扰影响的安全性被提高到这样的程度,即在大多数情况下,这个数目可足以使信号或消息的交换变得可靠和排他,但是在特殊情况下,可以使用更大的数目,并且获得了抵抗相互干扰和外来干扰的安全程度,这样就可以与密码锁相比。

The liability of a receiver being affected by disturbances emanating from other sources, as well as that of the signals or messages being received by instruments for which they are not intended may, however, be reduced not only by an increased number of the co-operative disturbances or series of impulses, but also by a judicious choice of the same, order and mode in which they are made to act upon the receiver.

然而,接收器被其它源发射出的扰动所影响的不利因素,以及这些信号或信息被仪器接收的不利因素,不仅可以通过增加协同扰动或脉冲序列的数量,而且可以通过明智地选择扰动或脉冲以及它们作用于接收器的顺序和模式来降低。

Evidently there are a great many ways of generating impulses or disturbances of any wave-length, wave-form, number or order of succession, or of any desired special character, such as will be capable of fulfilling the requirements above stated, and there are also many ways in which such impulses or disturbances may be made to co-operate and to cause the receiver to be actuated and, inasmuch as the skill and practical knowledge in these novel fields can only be acquired by long experience, the degree of safety and perfection attained will necessarily depend on the ability and resource of the expert who applies my invention, but in order to enable the same to be successfully practised by any person possessed only of the more general knowledge and experience in these branches, I shall describe the simplest plan of carrying it out, which is at present known to me.

显然,有很多种方法可以产生能够满足上述要求的任何波长、波形、数量或者任何连续顺序的、或者任何期望的特殊特性的脉冲或扰动,并且也有许多方法可以使这种脉冲或扰动协同工作并使接收器启动,因为这些新领域的技能和实践知识只能通过长期的经验获得,所达到的安全和完善的程度将必然取决于应用我的发明的专家的能力和资源,但为了使任何仅具有这些分支的一般知识和经验的人能够成功地实践同样的方法,我将描述执行它的最简单的方案,这是目前我所知道的。

For a better understanding of the subject, reference is now made to the drawing, in which. Fig. 1 and Fig. 2 represent diagrammatically the apparatus and circuit connections at the sending and receiving stations, respectively, and Figs. 3, 4 and 5 modified means which may be employed in the practical application of my invention. In Fig. 1 S^1 and S^2 are two spirally wound coils or conductors, connected with their inner ends to preferably elevated terminals D^1 and D^2 respectively, and with their outer ends to an earth plate E. These two coils, conductors or systems $D^1 S^1 E$ and $D^2 S^2 E$ have different and suitably chosen periods of vibration and, their lengths should be such that the points of maximum pressure developed therein coincide with the elevated terminals $D^1 D^2$. By suitably chosen periods of vibration such periods are meant as will secure the greatest safety against interference, both mutual and

extraneous. The most satisfactory results in this respect, are obtained when the different periods are related as the reciprocals of the smallest relative prime numbers, but whether this relation be observed or not, the vibrations should be so selected as to give, when passing through or acting upon a common path or circuit, the greatest practicable number of beats in the same. They should furthermore, as regards pitch, not approach too closely those of the order of the Hertzian, because with vibrations of such transcending rates, owing to the rapid radiation of energy into space, resonating systems, as $D^1 S^1 E$ and $D^2 S^2 E$ will not prove efficient intensifiers. The two systems may have electrical oscillations impressed upon them in any desired manner, conveniently by energizing them through primaries P^1 and P^2 , placed in proximity to them. Adjustable inductances L^1 and L^2 are preferably included in the primary circuits chiefly for the purpose of regulating the rate of the primary oscillations. In the drawing these primaries P^1 and P^2 surround the coils $S^1 S^2$, and are joined in series through inductances $L^1 L^2$, conductor F , condensers C^1 and C^2 , brush-holders B^1 and B^2 and a toothed disk D , which is connected to the conductor F and, if desired, also to the groundplate E , as shown, two independent primary circuits being thus formed. The condensers C^1 and C^2 are of such capacity and the inductances L^1 and L^2 are so adjusted that each primary is in close resonance with its secondary system. Care should be taken to obtain in each of the secondary systems $D^1 S^1 E$ and $D^2 S^2 E$ the true or fundamental note, as otherwise the apparatus may not perform satisfactorily. Assuming the capacities of the conductors S^1 and S^2 relatively small, the true notes will result when the product of capacity and inductance in each of the primaries is approximately equal to four times this product in each of the secondaries. The brush-holders B^1 and B^2 are capable, independently of angular and, if necessary, also of lateral adjustment, so that any desired order of succession or any difference of phase may be obtained between the discharges occurring in the two primary circuits. The condensers being energized from a suitable source S , preferably of high potential, and the disk D being rotated, its projections or teeth p , coming at periodically recurring intervals in very close proximity to or, as the case may be, in contact with conducting rods or brushes n , cause the condensers to be discharged in rapid succession through their respective circuits. In this manner the two secondary systems, $D^1 S^1 E$ and $D^2 S^2 E$, are set in vibration and oscillate freely, each at its proper rate for a certain interval of time at every discharge. The two vibrations are impressed upon the ground through the plate E , and spread to a distance, reaching the receiving station, which has two similar circuits or systems $e s^1 d^1$ and $e s^2 d^2$, arranged and connected in the same manner and synchronized with the systems at the sending station, so as to respond each exclusively to one of the two vibrations of one kind or class produced by the transmitting apparatus. The same rules of adjustment are observed in the receiving circuits, care being furthermore taken that the synchronizing be effected when all the apparatus is connected to the circuits and placed in position, as any change may more or less modify the vibration. Each of the receiving coils s^1 and s^2 is shunted by a local circuit containing, respectively, sensitive devices $a^1 a^2$, batteries $b^1 b^2$, adjustable resistances $r^1 r^2$ and sensitive relays $R^1 R^2$, all joined in series as shown. The precise connections and arrangements of the various instruments are largely immaterial, and may be varied in a great many ways. The sensitive devices a^1 and a^2 may be any of the well-known devices, as for example, two conducting terminals separated by a minute air-gap or thin film of dielectric, which is strained or weakened by a battery or other means to the point of breaking down, and gives way to the slightest disturbing influence. Its return to the normal sensitive state may be secured by momentarily interrupting the battery circuit after each operation, or otherwise. The relays $R^1 R^2$ have armatures $l^1 l^2$, which are connected by a wire w , and when attracted, establish electrical contacts at c^1 and c^2 , thus closing a circuit containing a battery b^3 , an adjustable resistance r^3 and a relay R^3 . From the above description it will be readily seen that the relay R^3 will be operated only when both contacts c^1 and c^2 are closed.

为了更好地理解该主题，现在参考附图，其中图 1 和图 2 分别示意性地表示了发送站和接收站的一个设备和多个电路连接，图 3、图 4 和图 5 表示了可以在我的发明的实际应用中使用的改进后工具。在图 1 中， S^1 和 S^2 是两个螺旋缠绕的线圈或导体，它们的内部末端最好分别连接到高架终端 D^1 和 D^2 上，它们的外部末端连接到一块接地板 E 。这两个线圈、导体或系统 $D^1 S^1 E$ 和 $D^2 S^2 E$ 具有不同的和适当选择的振动周期，它们的长度应使其中产生的最大压力（电压）点与 $D^1 D^2$ 高架终端重合。通过适当选择振动周期，这种周期意味着将确保最大程度的安全性，防止相互干扰和外来干扰。在这方面最令人满意的结果，是当不同的周期被关联为最小相对素数的倒数时，但无论这种关系是否被观察到，振动应该这样选择，当振动通过或作用于一个共同的路径或电路时，在该共同的路径或电路中出现最大可行的节拍数。此外，就音高而言，它们不应该过于接近赫兹等级，因为如果使用了那种超速振动，会导致能量快速辐射到空间中，如 $D^1 S^1 E$ 和 $D^2 S^2 E$ 的共振系统将不会证明是有效的增强器。可以以任何期望的方式向这两个系统施加电振荡，方便地通过放置在它们附近的初级线圈 P^1 和 P^2 来激励它们。可调电感 L^1 和 L^2 最好被包含在初级电路中，主要是为了调节初级振荡的速率。在图中，这些初级线圈 P^1 和 P^2 围绕着线圈 $S^1 S^2$ ，并通过电感 $L^1 L^2$ 、导体 F 、电容器 C^1 和 C^2 、电刷架 B^1 和 B^2 以及齿盘 D 串联连接，齿盘 D 连接到导体 F ，如果需要，还连接到接地板 E ，如图所示，这样就形成了两个独立的初级电路。 C^1 和 C^2 的电容器容量如此之大，并且电感 L^1 和 L^2 要如此调整，使得每个初级与其次级系统紧密谐振。应注意在 $D^1 S^1 E$ 和 $D^2 S^2 E$ 的每个次级系统中获取真实或基本的音符，否则仪器的性能可能不令人满意。假设导体 S^1 和 S^2 的电容相对较小，当每个初级中电容和电感的乘积大约等于每个次级线圈中电容和电感乘积的四倍时，就会产生真实的音符。电刷架 B^1 和 B^2 能够分别进行角度调节，并且如果需要的话，还能够进行横向调节，从而可以在两个初级电路中发生的放电之间获得任何期望的承继顺序或任何相位差。电容器由一个合适的电源 S (最好是高电位电源) 供电，圆盘 D 旋转，其突起或齿 p 在周期性重复的时间间隔内与导电杆或电刷 n 非常靠近或接触（视情况而定），使电容器通过它们各自的电路快速连续地放电。以这种方式两个次级系统， $D^1 S^1 E$ 和 $D^2 S^2 E$ ，被设置成自由地振动和振荡，每个都设置在其适当的速率上用于在每次放电时获得一定的时间间隔。这两个振动通过板 E 施加在接地上，并传播一段距离，到达接收站，该接收站具有两个类似的电路或系统 $e s^1 d^1$ 和 $e s^2 d^2$ ，它们以相同的方式布置和连接，并与发送站的系统同步，以便各自排他地响应由发送装置产生的一种或一类两个振动中的一个。在接收电路中观察到相同的调整规则，此外还要注意，当所有设备都连接到电路并放置到位时，同步才有效，因为任何变化都可以或多或少地改变振动。接收线圈 s^1 和 s^2 中的每一个都被一个局部电路分流，该局部电路分别包含敏感设备 $a^1 a^2$ 、电池 $b^1 b^2$ 、可调电阻 $r^1 r^2$ 和敏感继电器 $r^1 r^2$ ，所有这些都如图所示串联连接。各种仪器的精确连接和排列在很大程度上是不重要的，并且可以以许多方式变化。敏感装置 a^1 和 a^2 可以是任何众所周知的装置，例如，由微小的空气间隙或电介质薄膜分开的两个导电终端，空气间隙或电介质薄膜被电池或其它装置应变或削弱到击穿的程度，并让路于最轻微的扰动影响。可以通过在每次操作后暂时中断电池电路或其他工具来确保其返回到正常的敏感状态。继电器 $R^1 R^2$ 具有由一个导线 w 连接的衔铁 $l^1 l^2$ ，并且当衔铁被吸引时，在 c^1 和 c^2 处建立电接触，从而闭合了包含电池 b^3 、可调电阻 r^3 和继电器 R^3 的电路。从上面的描述中很容易看出，继电器 R^3 只有在触点 c^1 和 c^2 都闭合时才会工作。

The apparatus at the sending station may be controlled in any suitable manner, as, for instance, by momentarily closing the circuit of the source S , two different electrical vibrations being emitted simultaneously or in rapid succession, as may be desired, at each closure of the circuit. The two receiving circuits at the distant station, each responding to the vibration produced by one of the elements of the transmitter, affect the sensitive devices a^1 and a^2 and cause the relays R^1 and R^2 to be operated and

contacts c^1 and c^2 closed, thus actuating the receiver or relay R^3 , which in turn establishes a contact c^3 and brings into action a device a^3 by means of a battery b^4 included in a local circuit, as shown. But evidently, if through any extraneous disturbance only one of the circuits at the receiving station is affected, the relay R^3 will fail to respond. In this way communication may be carried on with much increased safety against interference, and privacy of messages may be secured. The receiving station shown in Fig. 2 is supposed to be one requiring no return message, but if the use of the system is such that this is necessary, then the two stations may be equipped similarly, and any well-known means, which it is not thought necessary to illustrate here, may be resorted to for enabling the apparatus at each station to be used in turn as transmitter and receiver.

发送站处的设备可以以任何合适的方式被控制，例如，通过短暂闭合源 S 的电路，在每次闭合电路时，根据需要，同时或快速承继地发射两种不同的电振动。在远处站点的两个接收电路，每一个都响应由发射器的组件中一个组件所产生的振动，这两个接收电路影响敏感装置 a^1 和 a^2 ，并使继电器 R^1 和 R^2 工作，也使得触点 c^1 和 c^2 闭合，从而启动接收器或继电器 R^3 ，这反过来建立了触点 c^3 ，并通过被包含在局部电路中的电池 b^4 使设备 a^3 开始工作，如图所示。但是很明显，如果通过任何外来扰动，只有接收站的一个电路受到影响，继电器 R^3 将不能响应。以这种方式，通信可以以更高的抗干扰安全性进行，并且可以保护消息的隐私。图 2 所示的接收站应该是一个不需要返回消息的站点，但是如果系统的使用使得这是必要的，那么两个站点可以被类似地装备，并且可以采用任何众所周知的装置，以使得每个站点的设备轮流被用作发射器和接收器，这些装置没有必要在此展示。

The terminals $D^1 D^2$ of the transmitting, and $d^1 d^2$ of the receiving apparatus are shown insulated from each other, but this, while advantageous, is not absolutely necessary, and each pair may be connected together, or else a single terminal, as D^1 or d^1 , may be used at either of the stations, instead of two, as illustrated.

发射装置的终端 $D^1 D^2$ 和接收装置的 $d^1 d^2$ 被显示为彼此绝缘，虽然这是有利的，但不是绝对必要的，每对终端可以连接在一起，或者如图所示，可以在任一站点使用单个终端，如 D^1 或 d^1 ，而不是两个。

In like manner the operation of a receiver, as R^3 , may be made dependent, instead of upon two, upon more than two such transmitting circuits or systems, and in this way any desired degree of exclusiveness or privacy and safety against extraneous disturbances may be attained. The apparatus, as illustrated in Fig. 1 and Fig. 2 permits, however, specific results to be secured by the adjustment of the order of succession or phase difference between the discharges of the primary circuits P^1 and P^2 . To illustrate, the action of the relays $R^1 R^2$ may be regulated either by adjusting the weights of the levers $l^1 l^2$, or the strength of the batteries $b^1 b^2$, or the resistances $r^1 r^2$, or otherwise, so that, when a certain order of succession or difference of phase between the discharges of the primary circuits P^1 and P^2 exists at the sending station, the levers l^1 and l^2 will close the contacts $c^1 c^2$ at the same instant, and thus operate the relay R^3 , but will fail to produce this result when the order of succession or difference of phase is another one. By these or similar means additional safety against disturbances from other sources may be obtained and, on the other hand, the possibility afforded of effecting the operation of signaling by varying the order of succession of the discharges in the two circuits. Instead of closing and opening the circuit of the source S , as before indicated, for the purpose of sending distinct signals, it may be convenient to merely alter the period of either of the transmitting circuits arbitrarily in any of the well-

known ways, as by varying the inductance of the primaries. It should be stated, furthermore, in regard to the apparatus illustrated in Fig. 2, that special and useful results are obtainable by connecting contacts c^1 and c^2 in multiple arc instead of in series, as shown, in which case the relay R^3 will be necessarily either provided with two windings each controlled by one of the contacts, or otherwise constructed or adjusted so that it will not operate unless both of the contacts are closed.

以类似的方式，如 R^3 的一个接收机的操作可以依赖于两个以上的这种发射电路或系统，而不是依赖于两个，并且以这种方式，可以获得任何期望程度的排他性或私密性以及对抗外来干扰的安全性。然而，如图 1 和图 2 所示的装置允许通过调节初级电路 P^1 和 P^2 放电之间的承继顺序或相位差来保证特定的结果。为了说明，继电器 R^1 R^2 的作用可以通过调节杠杆 l^1 l^2 的重量、或电池 b^1 b^2 的强度、或电阻 r^1 r^2 、或者其它方式来调节，使得当在发送站的初级电路 P^1 和 P^2 的放电之间存在一定承继的顺序或相位差时，杠杆 l^1 和 l^2 将同时闭合触点 c^1 c^2 ，从而操作继电器 R^3 ，但是当承继顺序或相位差是另一个顺序时，将不能产生这个结果。通过这些或类似的工具，可以获得额外的安全性，防止来自其他来源的干扰，另一方面，通过改变两个电路中放电的承继顺序，提供了实现信号操作的可能性。如上所述，为了发送不同的信号，不是闭合和断开源 S 的电路，而是以任何众所周知的方式，仅仅任意改变任一发射电路的周期可能是方便的，例如通过改变初级线圈的电感。此外，应该指出的是，关于图 2 所示的装置，通过将触点 c^1 和 c^2 连接成多弧而不是串联，可以获得特殊和有用的结果，如图所示，在这种情况下，继电器 R^3 将必须设置有两个绕组，每个绕组由其中一个触点控制，或者以其他方式构造或调整，使得除非两个触点都闭合，否则它将不工作。

Obviously there is no necessity for using transmitters with two or more distinct elements or circuits, as S^1 and S^2 , since a succession of waves or impulses of different characteristics may be produced by an instrument having but one such circuit. A few of the many ways which will readily suggest themselves to the expert who applies my invention, are illustrated in Figs. 3, 4 and 5. In Fig. 3 a transmitting system e^3d^3 is partly shunted by a rotating wheel or disk D^3 , which may be similar to that illustrated in Fig. 1, and which cuts out periodically a portion of the coil or conductor s^3 , or, if desired, bridges it by an adjustable condenser C^3 , thus altering the vibration of the system e^3d^3 at suitable intervals and causing two distinct kinds or classes of impulses to be emitted in rapid succession by the sender. In Fig. 4 a similar result is produced in the system e^4d^4 by periodically short-circuiting a secondary p^4 , through an induction coil L^3 and a rotating disk D^4 with insulating and conducting segments, or otherwise. Again, in Fig. 5 three distinct vibrations are caused to be emitted by a system e^5d^5 , the result being produced by inserting periodically a suitable number of turns of an induction coil L^4 in series with the oscillating system by means of a rotating disk D^5 with two projections p^5p^5 , and three rods or brushes n^5 , placed at an angle of one hundred and twenty degrees relative to each other. The three transmitting systems or circuits last described may be energized as those in Fig. 1 or in any other convenient way. Corresponding to each of these cases, the receiving station may be provided with two or three circuits, in an analogous manner to that illustrated in Fig. 2, it being understood, of course, that the different vibrations or disturbances emitted by the sender follow in such rapid succession upon each other that they are practically simultaneous, as far as the operation of the relays, such as R^1 and R^2 is concerned. Evidently, however, it is not necessary to employ two or more receiving circuits as s^1 and s^2 , but single circuits may be used also at the receiving stations, constructed and arranged like the transmitting circuits or systems illustrated in Figs. 3, 4 and 5, in which case the corresponding disks, as D^3 , D^4 , D^5 at the sending will be driven in synchronism with those at the receiving stations, though this will not always be necessary.

显然，没有必要使用具有两个或更多不同组件或电路的发射器，如 S^1 和 S^2 ，因为一个仪器只有一个这样的电路就可以产生一连串的具有不同特性的波或脉冲。图 3、图 4 和图 5 展示了应用我的发明的专家容易想到的许多方法中的一些。在图 3 中，一个发射系统 $e s^3 d^3$ 被一个旋转的轮或盘 D^3 部分地分流，该轮或盘 D^3 可以类似于图 1 所示的轮或圆盘，并且它周期性地排除线圈或导体 s^3 的一部分，或者，如果需要的话，通过一个可调节的电容器 C^3 将其桥接，从而以适当的时间间隔改变系统 $e s^3 d^3$ 的振动，并且使得发送机接连不断地发射两种不同种类或类别的脉冲。在图 4 中，通过感应线圈 L^3 和具有绝缘和导电部分的旋转圆盘 d^4 ，或其他方式，周期性地短路次级 p^4 ，在系统 $e s^4 d^4$ 中产生类似的结果。同样，在图 5 中，系统 $e s^5 d^5$ 发出三种不同的振动，其结果是通过周期性地插入感应线圈 L^4 的适当匝数而产生的，该感应线圈 L^4 借助于具有两个突起 $p^5 p^5$ 和三个杆或电刷 n^5 的旋转圆盘 D^5 与振荡系统串联，这三个杆或电刷 n^5 相对于彼此以 120 度的角度放置。最后描述的三个发射系统或电路可以像图 1 中的那样或以任何其他方便的方式被激励。对应于这些情况中的每一种，接收站可以以类似于图 2 所示的方式设置有两个或三个电路，当然可以理解的是，由发射器发出的不同振动或扰动以如此快的接连不断地相继出现，就 R^1 和 R^2 这样的继电器的操作而言，以至于它们实际上是同时发生的。然而，很明显，没有必要采用如 s^1 和 s^2 那样的两个或更多的接收电路，但是在接收站也可以使用单个电路，像图 3、4 和 5 所示的发射电路或系统那样构造和安排，在这种情况下，在发送端的相应转盘，如 D^3 、 D^4 、 D^5 ，将与接收站的那些转盘同步驱动，尽管这并不总是必要的。

The disks or other circuit controlling devices, operating synchronously at both the stations, may be constructed so as to enable the transmission of the impulses in any desired fixed or varying order of succession; and it is to be remarked that they will afford additional safety against interference in this instance, while they might prove ineffective in ordinary systems in which but one kind of disturbance is employed to operate a receiver.

在两个站点同步运行的圆盘或其他电路控制装置可以被构造成能够以任何期望的固定或变化的承继顺序传输脉冲；要注意的是，在这种情况下，它们将提供额外的抗干扰安全性，而在普通系统中，它们可能被证明是无效的，在普通系统中，只有一种扰动被用来操作接收器。

To illustrate other useful features, reference may be again made to Figs. 1 and 2. I have found no difficulty in modifying the transmitting apparatus shown in Fig. 1 in such a way, that it will emit, instead of two, four vibrations of different periods. I accomplish this result by properly adjusting the inductances and capacities and the mutual induction coefficients of the two primary and secondary systems. During the time interval when a primary circuit, as P^1 , is closed by the make and break device $B^1 D B^2$, the secondary circuit S^1 in inductive relation to it may be made to vibrate at a different and considerably higher rate, owing to the diminution of its coefficient of self-induction through the mutual induction of the circuits, and by proper adjustments of the quantities above named four oscillations of suitable frequency are generated by the transmitter. This being the case, the receiving station may be provided with two sets of apparatus, as illustrated in Fig. 2, and there will then be four relays or devices as $R^1 R^2$, which may be cooperatively connected or associated either in the manner shown in Fig. 2 or in any other convenient way, but so, that the desired effect upon a receiver will be produced only when all four receiving circuits are energized, and will not take place under any other circumstances.

为了说明其他有用的特征，可以再次参考图 1 和图 2。我发现以这种方式修改图 1 所示的发射装置没有困难，即它将发射四个不同周期的振动，而不是两个。我通过适当调整两个初级

和次级系统的电感和电容以及互感系数来实现这个结果。在初级电路，如 P^1 ，被通断装置 B^1 D B^2 闭合的时间间隔期间，与它有感应关系的次级电路 S^1 可以以不同的和相当高的速率振动，这是由于通过电路的互感降低了它的自感系数，并且通过适当调整上述量，发射器产生四个适当频率的振荡。在这种情况下，如图 2 所示，接收站可以配备两套装置，于是将有四个继电器或装置，如 R^1 R^2 ，它们可以以图 2 所示的方式或任何其他方便的方式协同连接或关联，但是这样，只有当所有四个接收电路都被激励时，才会产生对一个接收器的期望效果，而这在任何其他情况下都不会发生。

When it is desired to modify the apparatus as and for the purpose above stated, the various quantities may be determined as follows: Designating, for the sake of convenience, by letters D^1 and S^1 respectively the terminal capacity and the inductance of the secondary system, its fundamental note, when the primary is open, will be of a suitably selected period $T^1 = \frac{1}{n^1 k} = \frac{2\pi}{10^3} \sqrt{4D^1 S^1 D^1}$ expressing the capacity of the elevated terminal in microfarads and S^1 the inductance of the secondary coil in Henrys. In conformity with the preceding the influence of the primary circuit should be so regulated that, when it is closed by the make and break device D the vibration in the secondary will be of a smaller and

arbitrarily chosen period $T^2 = \frac{1}{n^2 k}$ such that $\frac{T^1}{T^2} = \frac{\frac{1}{n^1 k}}{\frac{1}{n^2 k}} = \frac{n^2}{n^1}$, n^2 and n^1 being, preferably, small relative prime numbers and k a constant.

为了上述目的，当希望修改该装置时，各种量可以确定如下：为了方便起见，分别用字母 D^1 和 S^1 表示次级系统的终端的容量和电感，当初级开路时，其基音将是一个适当选择的周期 $T^1 = \frac{1}{n^1 k} = \frac{2\pi}{10^3} \sqrt{4D^1 S^1 D^1}$ 用高架终端的容量 D^1 （单位为微法）和次级线圈的电感 S^1 （单位为亨利）来表示。与前面的一致，初级电路的影响应该被调节，当它被通断装置 D 闭合时，次级电路中的振动将是一个较小的和任意选择的周期 $T^2 = \frac{1}{n^2 k}$ 所以 $\frac{T^1}{T^2} = \frac{\frac{1}{n^1 k}}{\frac{1}{n^2 k}} = \frac{n^2}{n^1}$ ， n^2 和 n^1 最好是相对较小的质数， k 是一个常数。

Designating further, conveniently, the inductance of the primary turn or turns in inductive relation to the secondary by the letter P^1 , and the mutual induction coefficient by M , the inductance of the secondary, when the primary circuit is closed, will be reduced to a value $S^1 \left(1 - \frac{M^2}{P^1 S^1}\right)$ and the period

will be approximately $T^2 = \frac{2\pi}{10^3} \sqrt{4D^1 S^1 \left(1 - \frac{M^2}{P^1 S^1}\right)}$ Similarly, if letters C^1 and L^1 denote respectively

the capacity in the primary circuit and inductance of the adjustable primary coil, the period of the primary circuit will likewise be $T^2 = \frac{2\pi}{10^3} \sqrt{C^1 \left[L^1 + P^1 \left(1 - \frac{M^2}{P^1 S^1}\right)\right]}$ Either of the two expressions

found for T^2 may be used in the determinations of the quantities, but the latter is preferable, and it will be found most suitable in practice to ascertain the constants C^1 , P^1 , M and S^1 by measurement and calculate the approximate number of turns of coil L^1 , which permits of easy and precise adjustment by

actual experiment.

此外，方便地，用字母 P^1 表示与次级有感应关系的一匝或多匝的电感，用 M 表示互感系数，当初级电路闭合时，次级线圈的电感将减小到值 $S^1 \left(1 - \frac{M^2}{P^1 S^1}\right)$ ，并且周期近似等于

$T^2 = \frac{2\pi}{10^3} \sqrt{4D^1 S^1 \left(1 - \frac{M^2}{P^1 S^1}\right)}$ 。类似地，如果字母 C^1 和 L^1 分别表示初级电路中的电容和可

调初级线圈的电感，则初级电路的周期同样为 $T^2 = \frac{2\pi}{10^3} \sqrt{C^1 \left[L^1 + P^1 \left(1 - \frac{M^2}{P^1 S^1}\right)\right]}$ 为求得 T^2

而找到的两个表达式中的任何一个都可以用于确定数量，但后者是优选的，并会发现在实践中最适合通过测量来确定常数 C^1 、 P^1 、 M 和 S^1 ，并计算线圈 L^1 的近似匝数，这允许通过实际实验容易和精确地调整。

The above given values for the two periods of the resonating grounded system as $D^1 S^1 E$ hold good only when the conductors, as S^1 , are directly connected to the ground. When, as the case may be, a condenser is interposed in the ground connection, the values will be modified in a way well known to experts.

上述给出的谐振接地系统（如 $D^1 S^1 E$ ）的两个周期值，只有当导体（如 S^1 ）直接接地时才有效。当在接地连接中插入一个电容器时，这些值将以专家熟知的方式进行修改。

A difficulty may be experienced in securing the proper attunement of a number of circuits of different periods when, as in the instance last described, they are excited through a common medium or channel. The task will be facilitated by graduating the effects in the circuits, which may be done by the adjustment of the ratio of the inductance to the resistance, or otherwise. As a rule it will be found desirable to equalize the actions of the several circuits as much as possible. In connection with the above it is useful to state, that an advantage may be secured by the employment of a circuit-making and breaking device, similar to that illustrated in Fig. 5, for the purpose of connecting the four receiving circuits intermittently to the ground, instead of permanently, it being understood, of course, that the effect of the various circuits upon the receiver is practically simultaneous. Such a device is valuable also in ordinary systems, as, for instance, when it is desired to receive signals from a number of stations at the same time.

在确保不同周期的一些电路的适当协调方面可能会经历一个困难，正如在最后描述的例子中，它们通过一个共同的媒介或信道被激发。将电路中的效应分级将会促进该任务，这可以通过调整电感与电阻的比率或其他方式来实现。通常，会发现尽可能均衡几个电路的行动是可取的。结合以上所述，有必要说明，为了将四个接收电路间歇地而不是永久地连接到地，可以通过采用类似于图 5 所示的电路通断装置来获得优势，当然，应该理解，各种电路对接收器的影响实际上是同时的。这种设备在普通系统中也是有价值的，例如，当希望同时从多个站接收信号时。

By using a transmitter emitting four different vibrations or classes of impulses distinctive in their effect upon as many elements of a receiver, eleven receiving stations can be operated, that is, six by combining two of the vibrations, with great safety, four by combining three of the vibrations, with a safety

enormously increased, and one by combining all the four vibrations with a safety which, for most practical purposes, may be considered absolute. The various receivers will obviously be distributed to suit the importance of the several stations. The degree of safety, as well as the number of stations which may be selectively operated, can be still further increased by producing the impulses at the transmitting stations in any arbitrary order of succession which, if desired, may be continuously varied, and using them, at the various receiving stations, to actuate the receivers, in accordance with a predetermined understanding, code, key or safety combination.

通过使用发射器发射四种不同的振动或不同种类的脉冲,它们对一个接收器的许多组件的影响是不同的,可以操作十一个接收站,也就是说,六个通过非常安全地组合两种振动来操作,四个通过组合三种振动来操作,并具有大幅增加的安全性,一个通过组合所有四种振动来操作,对于大多数实际目的来说,可以认为是绝对安全的。显然,各种接收器将被分布以适应几个站的重要性。通过在发射站以任意的承继顺序产生脉冲,如果需要,这种顺序可以连续变化,并在不同的接收站使用它们,根据预定的理解、代码、密钥或安全组合启动接收器,可以进一步增加安全程度以及可以选择性操作的站的数量。

Obviously transmitters and receivers may be provided with a much greater number of distinctive elements which, combined and associated in every possible way, will permit the selective operation of a practically unlimited number of devices through a common natural or artificial channel, and such a degree of individualization of a receiver, that it will be absolutely secure against extraneous interference and may be safely called into action, whenever desired, from among innumerable devices of its kind.

显然,发射器和接收器可以配备更多数量的独特组件,这些组件以各种可能的方式组合和关联,将允许通过公共的自然的或人工的信道,以及接收器的这种个性化程度,对实际上无限数量的设备进行选择性操作,使得它将绝对安全地不受外来干扰,并且可以在需要时从无数同类设备中安全地调用。

It will be seen from a consideration of the nature and purposes of the invention, that it is applicable not only to the special system described, in which the transmission of the impulses is effected through the natural media, but to other systems for the transmission of telegraphic or telephonic signals or of energy for any purpose, and whatever be the medium through which the impulses are transmitted, that is to say, the broad principle of making the operation of a receiver dependent upon the conjoint or resultant action of two or more electrically different or tuned circuits is applicable not only to the special system of telegraphy described in which the electrical energy is transmitted through the natural media, but also to such systems as involve the use of a cable or wire as the conducting medium. Moreover, it is not necessary that the energy transmitted should be utilized to operate any special form of telegraphic instrument, or in fact any telegraphic instrument at all, as the receiver may be a relay or similar device which controls any other kind of device, such for example as the steering mechanism of a self propelled vessel. Therefore the invention is, broadly considered, one for the transmission and utilization in a special manner of electrical energy in general.

从对本发明的性质和目的的考虑中可以看出,它不仅适用于所描述的通过自然媒介实现脉冲传输的特殊系统,而且适用于用于任何目的的电报信号或电话信号或能量传输的其他系统,无论脉冲通过什么媒介传输,也就是说,使接收器的操作依赖于两个或多个电学上不同的或调谐的电路的联合或合成作用的广泛原理不仅适用于所描述的通过自然媒介传输电能的特

殊电报系统，而且适用于使用电缆或电线作为传导媒介的系统。此外，传输的能量不必用于操作任何特殊形式的电报设备，或者实际上根本不用操作任何电报设备，因为接收器可以是控制任何其他类型设备的继电器或类似设备，例如作为一个自推进船只的操舵机械装置。因此，从广义上讲，本发明被认为是一种以特殊方式传输和利用电能的发明。

Having now particularly described and ascertained the nature of the said invention and in what manner the same is to be performed, as communicated to me by my foreign correspondent, I declare that what I claim is:-

现在已经特别描述和确定了上述发明的性质和以何种方式执行上述发明，我的外国通信者传达给我，我宣布我主张的是：—

1. In a system for the transmission of energy, the combination with a receiver comprising a plurality of elements and dependent for operation upon their conjoint action, of a means for producing a plurality of distinctive kind of disturbances or impulses, severally adapted to actuate the elements of the receiver, as set forth.

1、在一个用于传输能量的系统中的一个工具和一个接收器的组合，该工具用于产生多种不同种类的扰动或脉冲，该接收器由多个组件组成，并依赖于这些组件的联合作用进行操作，如上所述。

2. In a system for the transmission of electrical energy, the combination with a receiver comprising a plurality of elements and dependent for operation upon their conjoint action, of a transmitter having a plurality of elements capable of severally producing distinctive kinds of disturbances or impulses, each kind being adapted to actuate one only of the elements of the receiver, as set forth.

2、在一个用于传输电能的系统中的一个发射器和一个接收器的组合，该发射器具有多个组件，这些组件能够分别产生不同种类的扰动或脉冲，每种扰动或脉冲适合于仅启动接收器的一个组件，该接收器依赖于这些组件的联合作用而进行操作，如上所述。

3. In a system for the transmission of electrical energy, the combination with a receiver comprising a plurality of elements and dependent for operation upon the conjoint action of two or more of the same, of a transmitter adapted to produce a plurality of distinctive kinds of disturbances or impulses, each kind being adapted to actuate one only of the elements of the receiver, as set forth.

3、在一个用于传输电能的系统中的一个发射器和一个接收器的组合，该发射器适于产生多种不同种类的扰动或脉冲，每种扰动或脉冲适于仅启动接收器的一个组件，该接收器由不同组件组成，它依赖于两个或多个组件的联合作用而进行操作，如上所述。

4. In a system for the transmission of electrical energy, the combination with means for producing two or more distinctive kinds of disturbances or impulses, of receiving circuits, each adapted to respond to the waves or impulses of one kind only, and a receiving device dependent for operation upon the conjoint action of the several receiving circuits, as set forth.

4、在一个用于传输电能的系统中的不同接收电路、一个接收设备和不同工具的组合，该类

接收电路的每一个只适合于对一种类型的波或脉冲做出响应,该接收设备依赖于不同接收电路的联合作用而进行操作,该类工具用于产生两种或两种以上不同类型的扰动或脉冲,如上所述。

5. In a system for the transmission of electrical impulses and the operation or control of signaling or other apparatus thereby, the combination with a transmitter adapted to produce two or more distinctive kinds or classes of disturbances or impulses, of sensitive receiving circuits, each adapted to respond to the impulses or disturbances of one kind or class only, and a receiving device dependent for operation upon the conjoint action of the sensitive circuits, as set forth.

5、在用于传输电脉冲、发送信号的和因此其他装置的操作或控制的一个系统中,不同的敏感接收电路、一个接收装置和一个发射器的组合,该类敏感接收电路的每一个适合于只响应一种或一类的脉冲或扰动;该接收装置依赖于不同敏感电路的联合作用进行操作,该发射器适合于产生两种或两种以上不同种类或类别的扰动或脉冲,如上所述。

6. In a system for the transmission of electrical impulses, and the operation or control of signaling, or other apparatus thereby, the combination with a transmitter adapted to produce two or more distinctive kinds or classes of disturbances or impulses, of sensitive circuits at the receiving point or station, each adapted to respond to the impulses or disturbances of one kind or class only, a local circuit arranged to be completed by the conjoint action of the sensitive circuits and a receiving device connected therewith, as set forth.

6、在用于传输电脉冲、发送信号的和因此其他装置的操作或控制的一个系统中,不同的敏感接收电路、一个局部电路和一个发射器的组合,该类敏感电路适合于在接收点或接收站只响应一种或一类的脉冲或扰动,该局部电路布置成由敏感电路和与之相连的一个接收设备的联合作用使其完整,该发射器适合于产生两种或更多不同种类或类别的扰动或脉冲,如上所述。

7. In a system for the transmission of electrical impulses and the operation or control of signaling or other apparatus thereby, the combination with a transmitting apparatus adapted to produce two or more distinctive kinds of disturbances or impulses, of means for varying the relations of the impulses of the several kinds, sensitive circuits each adapted to respond to the impulses or disturbances of one kind only, and a receiving apparatus dependent for operation upon the conjoint action of the sensitive circuits, as set forth.

7、在用于传输电脉冲、发送信号的和因此其他装置的操作或控制的一个系统中,存在一个组合,包括:一个发射装置,适用于产生两个或者更多有明显区别的扰动或脉冲;用于改变几种类型的脉冲之间关系的工具;不同的敏感电路,其中的每一个只响应一种类型的脉冲或扰动;依赖于不同敏感电路的联合作用而操作的一个接收器,如上所述。

8. In a system, such as herein described, the combination with a transmitter adapted to produce a plurality of distinctive kinds of electrical disturbances or impulses, of a receiving apparatus comprising a plurality of circuits, a sensitive device and a relay included in each circuit, and adjusted to respond to the impulses or disturbances of one kind only, and a receiving apparatus in a local circuit controlled by the relays and adapted to be completed by the conjoint action of all of said relays, as set forth.

8、在诸如本文所述的一个系统中，由一个接收装置和另一个接收装置以及一个发射器构成的组合，第一个接收装置由多个电路和被包含在一个电路中的一个敏感设备和一个继电器构成，该敏感设备和继电器并被调整成只对多种脉冲或扰动中的一种做出响应，第二个接收装置被不同的继电器控制并适于通过所有所述继电器的联合作用使其电路完整，该发射器适用于产生多种不同种类的电扰动或脉冲，如上所述。

9. In a system of the kind described, the combination with a transmitter adapted to produce two or more series of electrical oscillations or impulses of different frequencies, of a receiving apparatus comprising a plurality of sensitive circuits each tuned to respond to the impulses of one of the series produced by the transmitter, and a signaling device dependent for its operation upon the conjoint action of said circuits, as set forth.

9、在所述类型的一个系统中，由一个接收装置、一个信号传送装置和一个发射器构成的组合，该接收装置由不同的敏感电路组成，每个敏感电路被调谐以响应由该发射器产生的多种序列脉冲中的一种，该信号传送装置依赖所述敏感电路的联合作用进行操作，该发射器适用于产生不同频率的两个或多个序列的电振荡或脉冲，如上所述。

10. The combination with a plurality of transmitter elements, each adapted to produce a series of impulses or disturbances of a distinctive character, and means for controlling and adjusting the same, of a receiver having a plurality of sensitive circuits each adapted to be affected by one of the series of impulses only, and dependent for operation upon the conjoint action of all of said circuits, as set forth.

10、由一个接收器和多个发射器组件构成的组合，该接收器具有多个敏感电路，每个敏感电路适于仅受多种脉冲序列中的一种影响，并且依赖于所有所述敏感电路的联合作用进行操作，该发射器组件的每一个适于产生一连串的具有独特特征的脉冲或扰动，如上所述。

11. The combination with a transmitter adapted to produce series of electrical impulses or disturbances of distinctive character and in a given order of succession, of a receiving apparatus comprising elements adapted to respond to such impulses in a corresponding order, and dependent for operation upon the conjoint action of said elements, as set forth.

11、由一个接收装置和一个发射器构成的组合，该接收装置由具有能适于以相应顺序响应这类脉冲的组件，并依赖于所述组件的联合作用进行操作，该发射器适于产生一连串具有独特特征和给定承继顺序的电脉冲或扰动，如上所述。

12. In a receiving apparatus, the combination of a plurality of sensitive circuits, each tuned to respond to waves or impulses of a given kind or class, a receiving circuit controlled by the sensitive circuits and a device connected with the receiving circuit adapted to be operated when said circuit is completed by the conjoint action of two or more of the sensitive circuits, as set forth.

12、在一个接收装置中，由多个敏感电路和一个接收电路构成的组合，该敏感电路的每一个都被调谐以响应一个给定种类或类别的波或脉冲，该接收电路由不同的敏感电路和与接收电路连接的一个装置控制，当所述电路被两个或者更多敏感电路的联合作用完成时，该接收电路适于被操作，如上所述。

13. The method of operating distant receivers which consists in producing and transmitting a plurality of kinds or classes of electrical waves or impulses, actuating by the waves or impulses of each class one of the elements of a receiver, and controlling the operation of the receiver by the conjoint action of two or more of said elements, as set forth.

13、操作远程接收器的方法，该方法包括产生和发射多种或多类电波或脉冲，由这些电波或脉冲能激励一个接收器的每一类组件，并通过两个或多个所述组件的联合作用控制接收器的操作，如上所述。

14. The method of signaling which consists in producing and transmitting a plurality of kinds or classes of electrical waves or impulses, developing by the waves or impulses of each class a current in one of a plurality of receiving circuits and controlling by means of such circuits a local circuit, as set forth.

14、一种发射信号的方法，包括产生和发送多种特征或多种类型的电波或脉冲，还包括通过每种电波或脉冲在多个接收电路之一中产生电流，并通过这些电路控制一个局部电路，如上所述。

15. The method of signaling which consists in producing a plurality or series of waves or impulses differing from each other in character or order of succession, exciting by the waves or impulses of each series one of a plurality of receiving circuits and controlling by such circuits a local circuit, as set forth.

15、一种发送信号的方法，包括产生多个序列的在性质或承继顺序上互不相同的波或脉冲，由每一个序列的波或脉冲激励多个接收电路中的一个，并由这些电路控制一个局部电路，如上所述。

16. The method of signaling which consists in producing a plurality or series of waves or impulses, varying the character or order of succession of the several series, exciting by the waves or impulses of each series one of a plurality of receiving circuits and controlling by such circuits a local circuit, as set forth.

16、一种发送信号的方法，包括产生多个序列的波或脉冲，这些波或脉冲在特征或多个序列的承继顺序上有所不同，由每个序列的波或脉冲激励多个接收电路中的一个，并由这些电路控制一个局部电路，如上所述。

Dated this 16th day of July 1901.

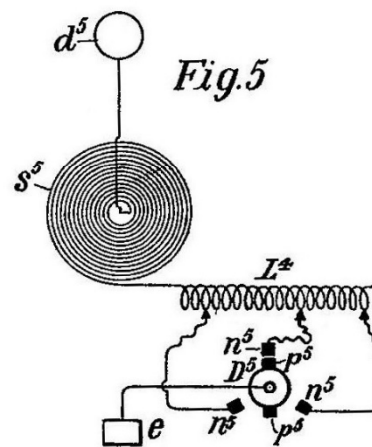
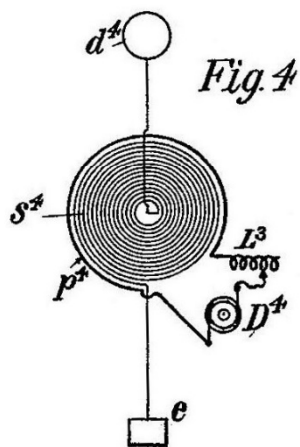
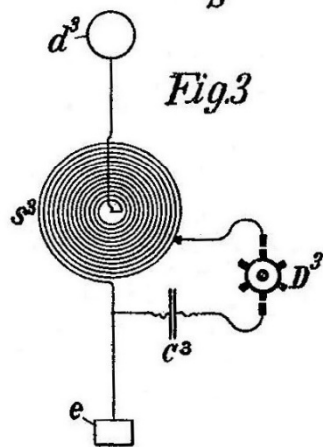
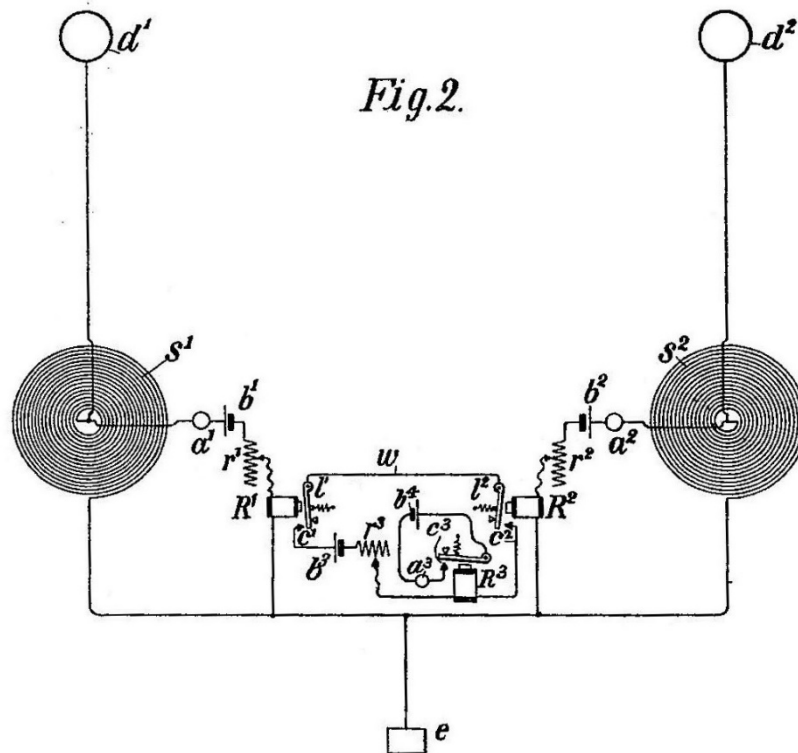
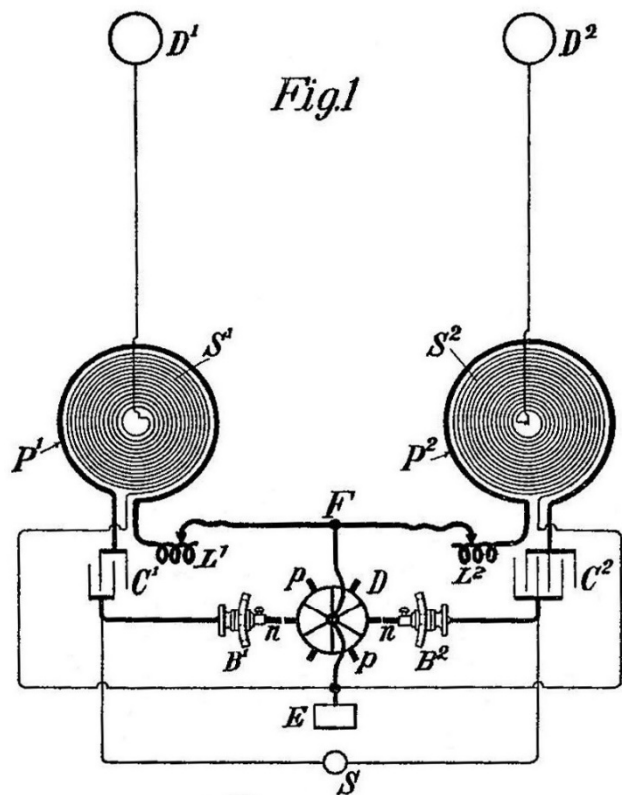
1901 年 7 月 16 日申请。

Haseltine, Lake & Co.,

45-Southampton Buildings, London, W.C., Agents for the Applicant.

哈兹尔廷（雷克）公司，

位于伦敦西中央区南安普敦大厦 45 号，代理申请。



SYSTEM OF SIGNALING

信号发送系统

NIKOLA TESLA, OF NEW YORK, N. Y.

纽约州纽约市的尼古拉·特斯拉

SPECIFICATION forming part of Letters Patent No. 725,605, dated April 14, 1903.

Application filed July 16, 1900. Serial No. 23,847. (No model.)

该说明书形成了颁发于 1903 年 4 月 14 日编号为 725,605 的专利证书的一部分。

申请日期是 1900 年 7 月 16 日。序列号 23847。(无模型)

To all whom it may concern:

致所有相关人员:

Be it known that I, NIKOLA TESLA, a citizen of the United States, residing in the borough of Manhattan, in the city, county, and State of New York, have invented certain new and useful Improvements in Systems of Signaling, of which the following is a specification, reference being had to the drawings accompanying and forming a part of the same.

众所周知，我，尼古拉·特斯拉，一名美国公民，居住在纽约州纽约郡纽约市的曼哈顿区，在信号发送系统方面已经发明了某些新的和有用的改进，以下是该发明一个说明书，必须参考随附的图纸，它已形成了该说明书的一部分。

In certain systems for transmitting intelligible messages or governing the movements and operations of distant automata electrical impulses or disturbances produced by suitable apparatus are conveyed through the natural media to a distant receiving-circuit capable of responding to the impulses, and thereby effecting the control of other appliances. Generally a special device highly sensitive is connected to the receiving-circuit, which in order to render it still more susceptible and to reduce the liability of its being affected by extraneous disturbances is carefully adjusted so as to be in tune with the transmitter. By a scientific design of the sending and receiving circuits and other apparatus and skillful adjustment of the same these objects may be in a measure attained; but in long experience I have found that notwithstanding all constructive advantages and experimental resources this method is in many cases inadequate. Thus while I have succeeded in so operating selectively under certain favorable conditions more than one hundred receivers in most cases it is practicable to work successfully but a few, the number rapidly diminishing as, either owing to great distance or other causes, the energy available in the tuned circuits becomes smaller and the receivers necessarily more delicate. Evidently a circuit however well constructed and adjusted to respond exclusively to vibrations of one period is apt to be affected by higher harmonics and still more so by lower ones. When the oscillations are of a very high frequency, the number of the effective harmonics may be large, and the receiver consequently easily disturbed by extraneous influences to such an extent that when very short waves, such as those produced by Hertzian spark apparatus, are used little advantage in this respect is derived from tuning the circuits. It being an imperative requirement in most practical applications of such systems of

signaling or intelligence transmission that the signals or messages should be exclusive or private, it is highly desirable to do away with the above limitations, especially in view of the fact, which I have observed, that the influence of powerful electrical disturbances upon sensitive receivers extends, even on land, to distances of many hundreds of miles, and consequently in accordance with theory still farther on sea.

在某些用于传输可理解的信息或控制远程自动装置的运动和操作的系统中,由合适的设备产生的电脉冲或扰动通过自然媒介被传送到一个远处的接收电路,该接收电路能够响应脉冲,从而影响其他设备的控制。通常,一个高灵敏度的特殊装置被连接到接收电路,为了使该电路更易受影响并降低该电路受外界干扰导致的不利因素,该接收电路被仔细地与发射器同步。通过发送电路的和接收电路的以及其他设备的科学设计,还有熟练的调整,这些目的可以在一定程度上实现,但尽管拥有所有的建设性优势和实验资源,这种方法在许多情况下是不充分的。因此,虽然在某些有利的条件下,有选择地操作一百多个接收器是可行的,但在大多数情况下,有可能成功地工作的只有少数几个,由于距离远或其他原因,能成功地工作的接收器数量迅速减少,同步电路中可用的能量变得更小,因此接收器必然更精密。显然,一个电路,无论如何出色地构建和调整,以排他地响应一种周期的振动,都容易受到高次谐波的影响,尤其是受到基音的影响。当振荡频率很高时,有效谐波的数量可能很大,因此接收器很容易受到外来影响的干扰,以至于当采用非常短的波,如赫兹火花装置产生的波时,从调谐电路中得不到什么好处。在这种信号或情报的传输系统的大多数实际应用中,信号或消息应该是专有的或私有的,这是一个迫切的要求,因此,非常希望消除上述限制,更重要的是,因为这是一个事实,强大的电干扰对敏感接收器的影响甚至在陆地上延伸到数百英里的距离,因此,根据理论,在海上这种影响会延伸得更远。

To overcome these drawbacks and to enable a great number of transmitting and receiving stations to be operated selectively and exclusively and without any danger of the signals or messages being disturbed, intercepted, or interfered with in any way is the object of my present invention.

为了克服这些缺点,并使大量的发射站和接收站有选择地和排外地工作,而没有任何信号或消息被干扰或截获或以任何方式被妨碍的危险,这是我的目前发明的目的。

Broadly stated, this invention consists in the combination of means for generating and transmitting two or more kinds or classes of disturbances or impulses of distinctive character with respect to their effect upon a receiving-circuit and a distant receiver which comprises two or more circuits of different electrical character or severally tuned, so as to be responsive to the different kinds or classes of impulses and which is dependent for operation upon the conjoint or resultant action of the two or more circuits or the several instrumentalities controlled or operated thereby. By employing only two kinds of disturbances or series of impulses instead of one, as has heretofore been done to operate a receiver of this kind, I have found that safety against the disturbing influences of other sources is increased to such an extent that I believe this number to be amply sufficient in most cases for rendering the exchange of signals or messages reliable and exclusive; but in exceptional instances a greater number may be used and a degree of safety against mutual and extraneous interference attained, such as is comparable to that afforded by a combination-lock. The liability of a receiver being affected by disturbances emanating from other sources, as well as that of the signals or messages being received by instruments for which they are not intended, may, however, be reduced not only by an increased number of the cooperative disturbances or series of impulses, but also by a judicious choice of the same and the order in which

they are made to act upon the receiver.

概括地说，本发明包括用于产生和发送两种或多种类型或种类的扰动或脉冲的装置的组合，所述扰动或脉冲就其对接收电路的影响而言具有独特的特征，并且远程接收器包括两个或多个具有不同电特征或各自调谐的电路，以便响应不同类型或种类的脉冲，并且其操作依赖于两个或多个电路或由其控制或操作的若干装置的联合或合成作用。通过仅使用两种扰动或两个序列的脉冲而不是一种，正如迄今为止操作这种类型的接收器所做的那样，我发现对其他源的干扰影响的安全性增加到这样的程度，即我相信这个数目在大多数情况下足以使信号或消息的交换变得可靠和排他；但是在特殊情况下，可以使用更大的数量，并且获得一定程度的防止相互干扰和外来干扰的安全性，这样就可以与密码锁相比。然而，接收器受来自其它源的干扰影响的可能性，以及信号或信息被仪器接收到的可能性，不仅可以通过增加协同干扰或脉冲序列的数量来降低，而且可以通过明智地选择扰动或脉冲以及它们作用于接收器的顺序来降低。

Evidently there are a great many ways of generating impulses or disturbances of any wave length, wave form, number or order of succession, or of any special character such as will be capable of fulfilling the requirements above stated, and there are also many ways in which such impulses or disturbances may be made to cooperate and to cause the receiver to be actuated, and inasmuch as the skill and practical knowledge in these novel fields can only be acquired by long experience the degree of safety and perfection attained will necessarily depend upon the ability and resource of the expert who applies my invention; but in order to enable the same to be successfully practiced by any person possessed only of the more general knowledge and experience in these branches I shall describe the simplest plan of carrying it out which is at present known to me.

显然，有很多种方法可以产生能够满足上述要求的任何波长、波形、数量或者任何连续顺序的、或者任何期望的特殊特性的脉冲或扰动，并且也有许多方法可以使这种脉冲或扰动协同工作并使接收器启动，因为这些新领域的技能和实践知识只能通过长期的经验获得，所达到的安全和完善的程度将必然取决于应用我的发明的专家的能力和资源，但为了使任何仅具有这些分支的一般知识和经验的人能够成功地实践同样的方法，我将描述执行它的最简单的方案，这是目前我所知道的。

For a better understanding of the subject reference is now made to the accompanying drawings, in which—

为了更好地理解主题，现在参考附图，其中—

Figures 1 and 2 represent diagrammatically the apparatus and circuit connections employed at the sending and receiving stations, respectively; and Figs. 3, 4, and 5 modified means which may be employed in the practical application of the invention.

图 1 和 2 分别示意性地表示了发送站和接收站所采用的一个设备和多个电路连接；图 3、4 和 5 展示了可用于本发明实际应用的改进方法。

In Fig. 1, S^1 and S^2 are two spirally-wound coils or conductors connected with their inner ends to elevated terminals D^1 and D^2 , respectively, and with their outer ends to an earth-plate E. These two

coils, conductors, or systems $D^1 S^1 E$ and $D^2 S^2 E$ have different and suitably-chosen periods of vibration, and, as pointed out in other patents relating to my system of energy and intelligence transmission, their lengths should be such that the points of maximum pressure developed therein coincide with the elevated terminals $D^1 D^2$. The two systems may have electrical oscillations impressed upon them in any desired manner, conveniently by energizing them through primaries P^1 and P^2 , placed in proximity to them. Adjustable inductances L^1 and L^2 are preferably included in the primary circuits chiefly for the purpose of regulating the rates of the primary oscillations. In the drawings these primaries P^1 and P^2 surround the coils $S^1 S^2$ and are joined in series through the inductances $L^1 L^2$, conductor F , condensers C^1 and C^2 , brush-holders B^1 and B^2 , and a toothed disk D , which is connected to the conductor F and, if desired, also to the ground-plate E , as shown, two independent primary circuits being thus formed. The condensers C^1 and C^2 are of such capacity and the inductances L^1 and L^2 are so adjusted that each primary is in close resonance with its secondary system, as I have explained in other patents granted to me. The brush-holders B^1 and B^2 are capable independently of angular and, if necessary, also of lateral adjustment, so that any desired order of succession or any difference of time interval between the discharges occurring in the two primary circuits may be obtained. The condensers being energized from a suitable source S , preferably of high potential, and the disk D being rotated, its projections or teeth $p p$, coming at periodically-recurring intervals in very close proximity to or, as the case may be, in contact with conducting rods or brushes $n n$, cause the condensers to be discharged in rapid succession through their respective circuits. In this matter the two secondary systems $D^1 S^1 E$ and $D^2 S^2 E$ are set in vibration and oscillate freely, each at its proper rate, for a certain period of time at every discharge. The two vibrations are impressed upon the ground through the plate E and spread to a distance reaching the receiving-station, which has two similar circuits or systems $e s^1 d^1$ and $e s^2 d^2$ arranged and connected in the same manner and tuned to the systems at the sending-station, so that each responds exclusively to one of the two vibrations produced by the transmitting apparatus. The same rules of adjustment are observed with respect to the receiving-circuits, care being, furthermore, taken that the tuning is effected when all the apparatus is connected to the circuits and placed in position, as any change may more or less modify the vibration. Each of the receiving-coils s^1 and s^2 is shunted by a local circuit containing, respectively, sensitive devices $a^1 a^2$, batteries $b^1 b^2$, adjustable resistances $r^1 r^2$, and sensitive relays $R^1 R^2$, all joined in series, as shown. The precise connections and arrangements of the various receiving instruments are largely immaterial and may be varied in many ways. The sensitive devices $a^1 a^2$ may be any of the well-known devices of this kind—as, for example, two conducting-terminals separated by a minute air-gap or a thin film of dielectric which is strained or weakened by a battery or other means to the point of breaking down and gives way to the slightest disturbing influence. Its return to the normal sensitive state may be secured by momentarily interrupting the battery-circuit after each operation or otherwise. The relays $R^1 R^2$ have armatures $l^1 l^2$, which are connected by a wire w and when attracted establish electrical contacts c^1 and c^2 , thus closing a circuit containing a battery b^3 , and adjustable resistance r^3 , and a relay R^3 .

在图 1 中, S^1 和 S^2 是两个螺旋缠绕的线圈或导体, 它们的内端分别连到高架终端 D^1 和 D^2 , 它们的外端连接到一块接地板 E , 这两个线圈、导体或系统 $D^1 S^1 E$ 和 $D^2 S^2 E$ 具有不同的和适当选择的振动周期, 正如在其他专利中指出的关于我的能量和情报传输系统, 它们的长度应该是这样的, 最大压力点与升高的终端 $D^1 D^2$ 重合。这两个系统可以以任何期望的方式施加电振荡, 方便地通过放置在它们附近的初级线圈 P^1 和 P^2 来激励它们。可调电感 L^1 和 L^2 最好被包括在初级电路中, 主要是为了调节初级振荡的速率。在附图中, 这些初级线圈 P^1 和 P^2 围绕着线圈 $S^1 S^2$, 并通过电感 $L^1 L^2$ 、导体 F 、电容器 C^1 和 C^2 、电刷架 B^1 和 B^2 以及齿盘

D 串联连接，齿盘 D 连接导体 F，如果需要，还可连接到接地板 E，如图所示，这样就形成了两个独立的初级电路。 C^1 和 C^2 的电容器容量如此之大， L^1 和 L^2 的电感如此调整，以至于每个初级系统都与其次级系统紧密谐振，正如在授予给我的其他专利中所解释的那样。电刷架 B^1 和 B^2 能够独立地进行角度调节，并且如果需要的话，还能够进行横向调节，从而可以获得在两个初级电路中发生的放电之间的任何期望的承继顺序或任何时间间隔差异。电容器由一个合适的电源 S（最好是高电位电源）供电，圆盘 D 旋转，其突起或齿 pp 在周期性重复的时间间隔内与导电杆或电刷 nn 非常靠近或视情况而定进行接触，使电容器通过它们各自的电路快速连续地放电。在这种情况下，两个次级系统 $D^1 S^1 E$ 和 $D^2 S^2 E$ 都处于振动状态，并以各自适当的速率自由振荡，每次放电都会持续一段时间。这两个振动通过板 E 施加在地面上，并传播到一段距离到达接收站，接收站有两个类似的电路或系统 $es^1 d^1$ 和 $es^2 d^2$ ，它们以相同的方式布置和连接，并调谐到在发送站的系统，因此每个系统只响应由发送装置产生的两个振动中的一个。对于接收电路，观察到相同的调整规则，此外，注意当所有设备都连接到电路并放置在适当位置时，调谐是有效的，因为任何变化都可以或多或少地改变振动。接收线圈 s^1 和 s^2 中的每一个都被一个局部电路分流，该局部电路分别包含敏感设备 $a^1 a^2$ 、电池 $b^1 b^2$ 、可调电阻 $r^1 r^2$ 和敏感继电器 $R^1 R^2$ ，如图所示，所有这些都串联在一起。各种接收仪器的精确连接和布置在很大程度上是不重要的，并且可以以多种方式变化。敏感装置 $a^1 a^2$ 可以是这种类型的任何众所周知的装置——例如，由微小的空气间隙或电介质薄膜分隔的两个导电终端，空气间隙或电介质薄膜被电池或其他装置应变或削弱到击穿的程度，并让路于最轻微的扰动影响。可以通过在每次操作后或其他情况下暂时中断电池电路来确保它返回到正常的敏感状态。继电器 $R^1 R^2$ 具有衔铁 $l^1 l^2$ ，它们通过一根导线 w 连接，并且当衔铁被吸引时建立了电触点 c^1 和 c^2 ，从而闭合包含电池 b^3 、可调电阻 r^3 和继电器 R^3 的电路。

From the above description it will be readily seen that the relay R^3 will be operated only when both contacts c^1 and c^2 are closed.

从上面的描述中很容易看出，继电器 R^3 只有在触点 c^1 和 c^2 都闭合时才会工作。

The apparatus at the sending-station may be controlled in any suitable manner—as, for instance, by momentarily closing the circuit of the source S, two different electric vibrations being emitted simultaneously or in rapid succession, as may be desired, at each closure of the circuit. The two receiving-circuits at the distant station, each tuned to respond to the vibrations produced by one of the elements of the transmitter, affect the sensitive devices a^1 and a^2 and cause the relays R^1 and R^2 to be operated and contacts c^1 and c^2 to be closed, thus actuating the receiver or relay R^3 , which in turn establishes a contact c^3 and brings into action a device a^3 by means of a battery b^4 , included in a local circuit, as shown; but evidently if through any extraneous disturbance only one of the circuits at the receiving-station is affected the relay R^3 will fail to respond. In this way communication may be carried on with greatly-increased safety against interference and privacy of the messages may be secured. The receiving-station (shown in Fig. 2) is supposed to be one requiring no return message; but if the use of the system is such that this is necessary then the two stations will be similarly equipped and any well-known means, which it is not thought necessary to illustrate here, may be resorted to for enabling the apparatus at each station to be used in turn as transmitter and receiver. In like manner the operation of a receiver, as R^3 , may be made dependent, instead of upon two, upon more than two such transmitting systems or circuits, and thus any desired degree of exclusiveness or privacy and safety against extraneous disturbances may be attained. The apparatus as illustrated in Figs. 1 and 2 permits, however, special results to be secured by the adjustment of the order of succession of the discharge of the primary

circuits P^1 and P^2 or of the time interval between such discharges. To illustrate, the action of the relays R^1 R^2 may be regulated either by adjusting the weights of the levers l^1 l^2 , or the strength of the batteries b^1 b^2 , or the resistances r^1 r^2 , or in other well-known ways, so that when a certain order of succession or time interval between the discharges of the primary circuits P^1 and P^2 exists at the sending-station the levers l^1 and l^2 will close the contacts c^1 and c^2 at the same instant, and thus operate the relay R^3 , but it will fail to produce this result when the order of succession or the time interval between the discharges in the primary circuits is another one. By these or similar means additional safety against disturbances from other sources may be attained and, on the other hand, the possibility afforded of effecting the operation of signaling by varying the order of succession of the discharges of the two circuits. Instead of closing and opening the circuit of the source S , as before indicated, for the purpose of sending distinct signals it may be convenient to merely alter the period of either of the transmitting-circuits arbitrarily, as by varying the inductance of the primaries.

发送站处的设备可以以任何合适的方式控制，例如，通过暂时闭合电源 S 的电路，在每次闭合电路时，根据需要，同时或快速连续地发射两种不同的电振动。在远处站的两个接收电路，每个都被调谐以响应由发射机的组件中的一个组件所产生的振动，影响敏感装置 a^1 和 a^2 ，并使继电器 R^1 和 R^2 ，也使得触点 c^1 和 c^2 闭合，从而启动接收机或继电器 R^3 ，这反过来建立了触点 c^3 ，并通过被包含在局部电路中的一个电池 b^4 使装置 a^3 开始工作，如图所示；但是很明显，如果由于任何外来干扰，只有接收站的一个电路受到影响，继电器 R^3 将不能响应。以这种方式，通信可以在大大增加的抗干扰安全性的情况下进行，并且可以保护消息的隐私。接收站（如图 2 所示）应该是不需要返回消息的站；但是，如果系统的使用是必要的，那么两个站将被类似地装备，并且可以采用任何众所周知的装置，以使每个站的设备轮流被用作发射机和接收机，这些装置被认为没有必要在此展示。以类似的方式，如 R^3 的一个接收机的操作可以依赖于这样的多于两个的发射系统或电路，而不是依赖于两个发射系统或电路，因此可以获得任何预期的排他性或私密性以及对抗外来干扰的安全性。然而，图 1 和图 2 所示的装置允许通过调节初级电路 P^1 和 P^2 的放电承继顺序或这种放电之间的时间间隔来获得特殊的结果。为了说明，继电器 R^1 R^2 的作用可以通过调节杠杆 l^1 l^2 的重量，或电池 b^1 b^2 的强度，或电阻 r^1 r^2 ，或以其它众所周知的方式来调节，使得当在发送站的初级电路 P^1 和 P^2 的放电之间存在着某个承继顺序或时间间隔时，杠杆 l^1 和 l^2 将同时闭合触点 c^1 和 c^2 ，从而操作继电器 R^3 ，但是当初级电路中放电的承继顺序或时间间隔是另一个顺序时，它将不能产生这个结果。通过这些或类似的手段，可以获得额外的安全性，防止来自其他来源的干扰，另一方面，通过改变两个电路的放电承继顺序，提供了实现发送信号的可能性。如上所述，为了发送不同的信号，仅仅通过改变初级线圈的电感来任意改变任一发射电路的周期会是方便的，而不是闭合和断开电源 S 的电路。

Obviously there is no necessity for using transmitters with two or more distinct elements or circuits, as S^1 and S^2 , since a succession of waves or impulses of different characteristics may be produced by an instrument having but one such circuit. A few of the many ways which will readily suggest themselves to the expert who applies my invention are illustrated in Figs. 3, 4, and 5. In Fig. 3 a transmitting system e s^3 d^3 is partly shunted by a rotating wheel or disk D^3 , which may be similar to that illustrated in Fig. 1 and which cuts out periodically a portion of the coil or conductor s^3 or, if desired, bridges it by an adjustable condenser C^3 , thus altering the vibration of the system e s^3 d^3 at suitable intervals and causing two distinct kinds or classes of impulses to be emitted in rapid succession by the sender. In Fig. 4 a similar result is produced in the system e s^4 d^4 by periodically short-circuiting, through an induction-coil L^3 and a rotating disk D^4 with insulating and conducting segments, a circuit p^4 in inductive relation

to said system. Again, in Fig. 5 three distinct vibrations are caused to be emitted by a system $e s^5 d^5$, this result being produced by inserting periodically a suitable number of turns of an induction-coil L^4 in series with the oscillating system by means of a rotating disk B^5 with two projections $p^5 p^5$ and three rods or brushes n^5 , placed at an angle of one hundred and twenty degrees relatively to each other. The three transmitting systems or circuits thus produced may be energized in the same manner as those of Fig. 1 or in any other convenient way. Corresponding to each of these cases the receiving-station may be provided with two or three circuits in an analogous manner to that illustrated in Fig. 2, it being understood, of course, that the different vibrations or disturbances emitted by the sender follow in such rapid succession upon each other that they are practically simultaneous, so far as the operation of such relays as R^1 and R^3 is concerned. Evidently, however, it is not necessary to employ two or more receiving-circuits; but a single circuit may be used also at the receiving-station constructed and arranged like the transmitting circuits or systems illustrated in Figs. 3, 4, and 5, in which case the corresponding disks, as $D^3 D^4 D^5$, at the sending will be driven in synchronism with those at the receiving stations as far as may be necessary to secure the desired result; but whatever the nature of the specific devices employed it will be seen that the fundamental idea in my invention is the operation of a receiver by the conjoint or resultant effect of two or more circuits each tuned to respond exclusively to waves, impulses, or vibrations of a certain kind or class produced either simultaneously or successively by a suitable transmitter.

显然，没有必要使用具有两个或更多不同组件或电路的发射机，如 S^1 和 S^2 ，因为一个仪器只有一个这样的电路就可以产生一系列不同特性的波或脉冲。图 3、4 和 5 展示了应用我的发明的专家容易想到的许多方法中的一些。在图 3 中，发射系统 $e s^3 d^3$ 被一个旋转的轮或盘 d^3 部分分流，该轮或盘 d^3 可以类似于图 1 中所示的轮或盘 D^3 ，并且周期性地排除线圈或导体 s^3 的一部分，或者如果需要，通过可调节的电容器 C^3 将其桥接，从而以适当的时间间隔改变系统 $e s^3 d^3$ 的振动，并且使得发送器快速连续地发射两种不同种类或类别的脉冲。在图 4 中，通过感应线圈 L^3 和具有绝缘和导电部分的旋转圆盘 D^4 周期性地短路与所述系统成感应关系的电路 p^4 ，在系统 $e s^4 d^4$ 中产生类似的结果。同样，在图 5 中，由系统 $e s^5 d^5$ 导致的三种不同的振动，这一结果是通过借助于转盘 B^5 周期性地插入与振动系统串联的感应线圈 L^4 的适当匝数而产生的，该转盘 B^5 具有两个突出物 $p^5 p^5$ 和三个杆或刷 n^5 ，它们相对于彼此以 120 度的角度放置。如此产生的三个发射系统或电路可以以与图 1 相同的方式或以任何其他方便的方式被激励。对应于这些情况中的每一种，接收站可以以类似于图 2 所示的方式装备有两个或三个电路，当然，可以理解，由发送器发出的不同振动或扰动以如此快地连续不断地出现，就 R^1 和 R^3 这样的继电器的操作而言，以至于它们实际上是同时发生的。然而，显然没有必要采用两个或更多的接收电路；但是在接收站也可以使用单个电路，其结构和布置类似于图 3、4 和 5 中所示的发射电路或系统，在这种情况下，在发送端的相应转盘，如 $D^3 D^4 D^5$ ，将与接收站的那些转盘同步驱动，以保证所需的结果；但是不管所采用的具体设备的性质如何，可以看出，本发明的基本思想是通过两个或多个电路的联合或合成效应来操作接收器，每个电路都被调谐成排他性响应由一个合适的发射器同时或相继产生的特定种类或类别的波、脉冲或振动。

It will be seen from a consideration of the nature of the method hereinbefore described that the invention is applicable not only in the special manner described, in which the transmission of the impulses is effected through natural media, but for the transmission of energy for any purpose and whatever the medium through which the impulses are conveyed.

从上文所述方法的性质可以看出,本发明不仅适用于所述的通过自然媒介实现脉冲传输的特殊方式,而且适用于任何目的的能量传输,无论脉冲通过何种媒介传送。

What I claim is—

我主张的是—

1. In a system for the transmission of electrical energy, the combination with means for producing two or more distinctive kinds of disturbances or impulses, of receiving-circuits, each tuned to respond to the waves or impulses of one kind only, and a receiving device dependent for operation upon the conjoint action of the several receiving-circuits, as set forth.

1、在一个电能传输系统中,包括能产生两种或两种以上不同类型的扰动或脉冲的装置;还包括接收电路,每个接收电路只对一种类型的波或脉冲做出响应;以及依赖于几个接收电路的联合作用进行操作的接收装置,如上所述。

2. In a system for the transmission of electrical impulses and the operation or control, of signaling or other apparatus thereby, the combination with a transmitter adapted to produce two or more distinctive kinds or classes of disturbances or impulses, of sensitive receiving-circuits, each tuned to respond to the impulses or disturbances of one kind or class only, and a receiving device dependent for operation upon the conjoint action of the sensitive circuits, as set forth.

2、在一个用于传输电脉冲、发送信号的操作或控制的系统(或其他装置)中,包括适合于产生两种或多种不同类型或种类的扰动或脉冲的一个发射机;还包括灵敏接收电路,每个电路被调谐以只响应一种类型或种类的脉冲或扰动;还有一个接收装置,其操作依赖于灵敏电路的联合作用进行操作,如上所述。

3. In a system for the transmission of electrical impulses, and the operation or control of signaling, or other apparatus thereby, the combination with a transmitter adapted to produce two or more distinctive kinds or classes of disturbances or impulses, of sensitive circuits at the receiving point or station, each tuned to respond to the impulses or disturbances of one kind or class only, a local circuit arranged to be completed by the conjoint action of the sensitive circuits and a receiving device connected therewith, as set forth.

3、在一个用于传输电脉冲、发送信号的操作或控制的系统(或其他装置)中,包括一个适用于产生两种或两种以上不同类型或种类的扰动或脉冲的发射机;还包括在接收点或接收站的敏感电路,每个敏感电路只对一种或一种类型的脉冲或扰动做出响应;一个局部电路通过敏感电路和与之相连的一个接收设备的联合作用使其完整,如上所述。

4. In a system for the transmission of electrical impulses, and the operation or control of signaling or other apparatus thereby, the combination with a transmitting apparatus adapted to produce two or more distinctive kinds of disturbances or impulses, of means for varying the time intervals of the emission of the impulses of the several kinds, sensitive circuits each tuned to respond to the impulses or disturbances of one kind only, and a receiving apparatus dependent for operation upon the conjoint action of the sensitive circuits, as set forth.

4、在一个用于传输电脉冲、发送信号的操作或控制的系统（或其他装置）中，包括适合于产生两种或多种不同类型的扰动或脉冲的一个发射设备；还包括用于改变几种类型的脉冲发射的时间间隔的方法；每个敏感电路被调谐成只响应一种类型的脉冲或扰动；还有一个接收设备，它依赖敏感电路的联合作用进行操作，如上所述。

5. In a system, such as herein described, the combination with a transmitter adapted to produce a plurality of distinctive kinds of electrical disturbances or impulses, of a receiving apparatus comprising a plurality of circuits, a sensitive device and a relay included in each circuit, and each said circuit being tuned to respond to the impulses or disturbances of one kind only, and a receiving apparatus in a local circuit controlled by the relays and adapted to be completed by the conjoint action of all of said relays, as set forth.

5、在诸如本文所述的系统中，包括适于产生多种不同种类的电扰动或脉冲的发射器，还包括一个接收装置，它由多个电路构成；包括在每个电路中的一个敏感装置和一个继电器和每个所述电路被调谐为仅响应一种类型的脉冲或扰动；还有由继电器控制的在一个局部电路中的一个接收装置，它适于通过所有所述继电器的联合作用使其完整，如上所述。

6. In a system of the kind described, the combination with a transmitter adapted to produce two or more series of electrical oscillations or impulses of different frequencies, of a receiving apparatus comprising a plurality of sensitive circuits each tuned to respond to the impulses of one of the series produced by the transmitter, and a signaling device dependent for its operation upon the conjoint action of said circuits, as set forth.

6、在所述类型的一个系统中，包括产生不同频率的两个或多个序列的电振荡或脉冲的发射器，还包括由多个敏感电路构成的一个接收设备，每个敏感电路被调谐以响应由发射器产生的不同序列脉冲中的一个序列，还有依赖于所述电路的联合作用进行操作的一个信号设备，如上所述。

7. The combination with a plurality of transmitter elements, each adapted to produce a series of impulses or disturbances of a distinctive character, and means for controlling and adjusting the same, of a receiver having a plurality of sensitive circuits each tuned so as to be affected by one of the series of impulses only, and dependent for operation upon the conjoint action of all of said circuits, as set forth.

7、包括多个发射器组件，每个发射器组件适于产生一系列独特特征的脉冲或扰动；以及用于控制和调节这些脉冲或扰动的装置；还包括具有多个敏感电路的一个接收器，以便仅受多个序列脉冲的一个序列的影响，并且依赖于所有所述电路的联合作用进行操作，如上所述。

8. The combination with a transmitter adapted to produce series of electrical impulses or disturbances of distinctive character and in a given order of succession, of a receiving apparatus comprising tuned circuits responding to such impulses in a corresponding order, and dependent for operation upon the conjoint action of said elements, as set forth.

8、包括一种发射机，适于产生不同序列的具有独特特征和给定承继顺序的电脉冲或扰动，还包括一种接收装置，由按一个对应顺序响应这种脉冲的被调谐的电路所构成，并依赖所述

组件的联合作用进行操作，如上所述。

9. In a receiving apparatus, the combination with a plurality of sensitive circuits, severally tuned to respond to waves or impulses of a different kind or class, a receiving-circuit controlled by the sensitive circuits and a device connected with the receiving-circuits adapted to be operated when said circuit is completed by the conjoint action of two or more of the sensitive circuits, as set forth.

9、在一个接收装置中，包括多个敏感电路，分别被调谐以响应一个不同种类或类别的波或脉冲；还包含一个由敏感电路控制的一个接收电路；还有一个与接收电路连接的装置，当所述电路通过两个或多个敏感电路的联合作用使其完整时，该装置适于被操作，如上所述。

10. A system for the transmission of electrical energy, having in combination means for producing and transmitting two or more impulses of different periodicities to form a signal in a predetermined order of succession, as set forth.

10、一种电能传输系统，包含用于产生和传输两种或多种不同周期的脉冲的方法，以预定的承继顺序形成信号，如上所述。

11. In a system for the transmission of electrical energy, the combination with a transmitting apparatus comprising one or more circuits, means for impressing therein oscillations or impulses of different character and a receiving apparatus comprising a plurality of circuits each tuned to respond to the impulses of one kind produced by the transmitter and a receiver dependent for operation upon the conjoint action of the receiving-circuits, as set forth.

11、在一个电能传输系统中，包含一个发射装置，它由一个或多个电路构成；还包含用于在其中施加不同特性的振荡或脉冲的装置方法；还有一个接收装置，它由多个电路和一个接收器构成，每个电路被调谐以响应由发射器产生的一种脉冲，该接收器依赖接收电路的联合作用进行操作，如上所述。

12. In a system for the transmission of electrical energy, the combination with a transmitting apparatus comprising a transformer and means for impressing upon the secondary element of the same oscillations or impulses of different character, of a receiving apparatus comprising a plurality of circuits each tuned to the impulses of one kind emitted by the secondary of the transmitting-transformer, and a receiver dependent for operation upon the conjoint action of the receiving-circuits, as set forth.

12、在一个传输电能的系统中，包含一个发射装置，它由一个变压器和用于将不同特性的相同振荡或脉冲施加到次级组件上的装置方法；还包括一个接收装置，它由多个电路和一个接收器构成，每个电路被调谐到由发射变压器的次级所发射的一种脉冲，该接收器依赖于接收电路的联合作用进行操作，如上所述。

13. In a system for the transmission of electrical energy, the combination with a transmitting apparatus comprising a transformer and means for impressing upon the secondary elements of the same oscillations or impulses of different periodicities and in a given order of succession, of a receiving apparatus comprising a plurality of circuits each tuned to respond to the transmitted impulses of one period, and a receiver dependent for operation upon the conjoint action of the receiving-circuits, as set

forth.

13、在一个电能传输系统中，包括一个发射装置，它由一个变压器和用于将不同周期的相同振荡或脉冲以给定的承继顺序施加到次级组件上的装置方法；还包括一个接收装置，它由多个电路和一个接收器构成，每个电路被调谐以响应一种周期的发射脉冲，该接收器依赖于接收电路的联合作用进行操作，如上所述。

14. In a signaling system, the combination of means for generating a series of electrical impulses of different periodicities, receiving-circuits of differing electrical periods of vibration, and an indicating mechanism operated to give an intelligible indication only when currents are induced in the receiving-circuits in a predetermined order, as set forth.

14、在一个信号系统中，包括产生一系列不同周期的电脉冲的装置、不同电振动周期的接收电路和一个用于指示的机械装置，只有当在接收电路中按预定的顺序感应出电流时，该机械装置才能给出可理解的指示，如上所述。

15. In a system for the transmission of energy, the combination of two or more circuits differing with respect of one of their electrical constants, means for energizing said circuits, and an indicating mechanism operative only by conjoint action of two or more currents generated by waves from the sending-station, as set forth.

15、在一个能量传输系统中，包括两个或多个电路，这些电路的电常数中的一个是不同的，还有为所述电路供电的装置，以及一个用于指示的机械装置，该机械装置仅通过由来自发送站的波产生的两个或多个电流的联合作用来操作，如上所述。

16. In a system for the transmission of electrical energy, the combination with a transmitter adapted to produce electrical waves or oscillations varying in character in a predetermined order, of a receiving instrument responsive to said oscillations and dependent for operation upon the action thereof in a corresponding order, as set forth.

16、在一个能量传输系统中，包括适用于产生电波或振荡的一个发射器，所述电波或振荡的特征以预定顺序变化，还包括一个接收仪器，它响应所述振荡并依赖于一个相应的顺序的作用而进行操作，如上所述。

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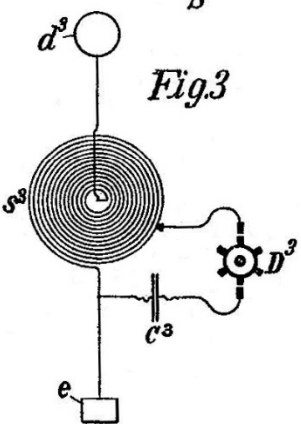
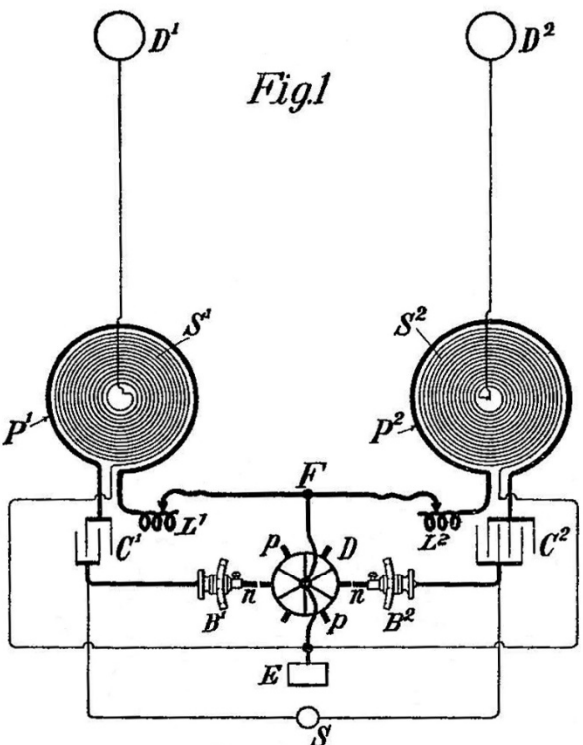
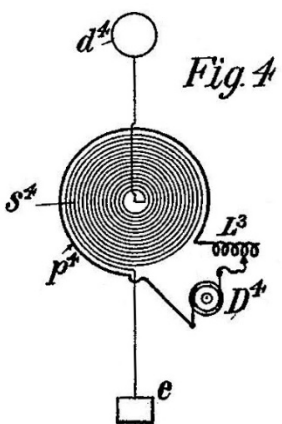
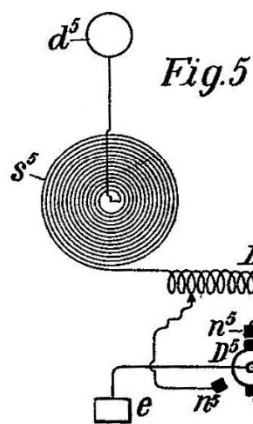
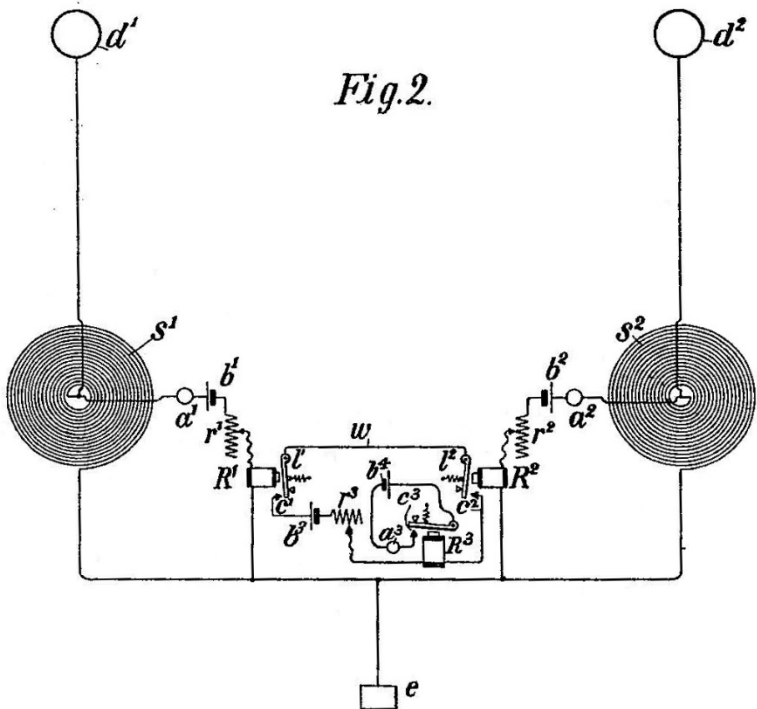
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NO MODEL.

N. TESLA.
SYSTEM OF SIGNALING.
APPLICATION FILED JULY 16, 1900.



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ART OF TRANSMITTING ELECTRICAL ENERGY THROUGH THE NATURAL MEDIUM

通过自然媒介传输电能的技术

SPECIFICATION forming part of Letters Patent No. 787,412, dated April 18, 1905.

Application filed May 16, 1900. Renewed June 17, 1902. Serial No. 113,034. (No model.)

说明书形成了颁发于 1905 年 4 月 18 日的专利证书 787,412 的一部分。

申请日期是 1900 年 5 月 16 日。1902 年 6 月 17 日更新。序列号 113034。(无模型)

To all whom it may concern:

致所有相关人士:

Be it known that I, NIKOLA TESLA, a citizen of the United States, residing in the borough of Manhattan, in the city, county, and State of New York, have discovered a new and useful Improvement in the Art of Transmitting Electrical Energy Through the Natural Media, of which the following is a specification, reference being had to the drawings accompanying and forming a part of the same.

众所周知，我，尼古拉·特斯拉，美国公民，居住在纽约州纽约郡纽约市的曼哈顿区，在通过自然媒介传输电能的技术方面已经发明了一种新的和有用的改进，以下是该发明一个说明书，必须参考随附的参考图纸，它已形成了该说明书的一部分。

It is known since a long time that electric currents may be propagated through the earth, and this knowledge has been utilized in many ways in the transmission of signals and the operation of a variety of receiving devices remote from the source of energy, mainly with the object of dispensing with a return conducting-wire. It is also known that electrical disturbances may be transmitted through portions of the earth by grounding only one of the poles of the source, and this fact I have made use of in systems which I have devised for the purposes of transmitting through the natural media intelligible signals or power and which are now familiar; but all experiments and observations heretofore made have tended to confirm the opinion held by the majority of scientific men that the earth, owing to its immense extent, although possessing conducting properties, does not behave in the manner of a conductor of limited dimensions with respect to the disturbances produced, but, on the contrary, much like a vast reservoir or ocean, which while it may be locally disturbed by a commotion of some kind remains unresponsive and quiescent in a large part or as a whole. Still another fact now of common knowledge is that when electrical waves or oscillations are impressed upon such a conducting-path as a metallic wire reflection takes place under certain conditions from the ends of the wire, and in consequence of the interference of the impressed and reflected oscillations the phenomenon of "stationary waves" with maxima and minima in definite fixed positions is produced. In any case the existence of these waves have reached the boundaries of the conducting-path and have been reflected from the same. Now I have discovered that notwithstanding its vast dimensions and contrary to all

observations heretofore made the terrestrial globe may in a large part or as a whole behave toward disturbances impressed upon it in the same manner as a conductor of limited size, this fact being demonstrated by novel phenomena, which I shall hereinafter describe.

很久以前就知道电流可以通过大地传播,并且这种知识已经以多种方式用于信号传输和远离能量源的各种接收设备的操作,主要目的是省去回路导线。众所周知,通过将电源的一个电极接地,电扰动会通过地球的一部分传播,这一事实我已经在系统中利用,我已经设计了这些系统,用于通过自然媒介传输可理解的信号或功率,这些信号或功率现在已为人们所熟悉;但迄今为止所有的实验和观察都倾向于证实大多数科学家的观点,即地球,由于其巨大的范围,虽然拥有导电属性,对于人为产生的扰动并不表现为一个有限尺寸的导体,相反,它很像一个巨大的水库或海洋,虽然它可能会受到某种扰动的局部干扰,但在很大程度上或整体上保持无反应和静止。现在众所周知的另一个事实是,当电波或振荡被施加在诸如金属导线的导电路径上时,在某些条件下从导线的端部发生反射,并且由于施加的振荡和反射的振荡的干涉,产生了在确定的固定位置具有最大值和最小值的“静态波”现象。在任何情况下,这些波的存在都已经到达传导路径的边界,并从该边界反射回来。现在我发现,尽管它的尺寸很大并且与迄今为止所做的所有观察相反,地球可能在很大程度上或作为一个整体对施加在其上的扰动的行为与有限尺寸的导体相同,这一事实被证明新的现象,我将在下文中描述。

In the course of certain investigations which I carried on for the purpose of studying the effects of lightning discharges upon the electrical condition of the earth I observed that sensitive receiving instruments arranged so as to be capable of responding to electrical disturbances created by the discharges at times failed to respond when they should have done so, and upon inquiring into the causes of this unexpected behavior I discovered it to be due to the character of the electrical waves which were produced in the earth by the lightning discharges and which had nodal regions following at definite distances the shifting source of the disturbances. From data obtained in a large number of observations of the maxima and minima of these waves I found their length to vary approximately from twenty-five to seventy kilometers, and these results and certain theoretical deductions led me to the conclusion that waves of this kind may be propagated in all directions over the globe and that they may be of still more widely differing lengths, the extreme limits being imposed by the physical dimensions and properties of the earth. Recognizing in the existence of these waves an unmistakable evidence that the disturbances created had been conducted from their origin to the most remote portions of the globe and had been thence reflected, I conceived the idea of producing such waves in the earth by artificial means with the object of utilizing them for many useful purposes for which they are or might be found applicable. This problem was rendered extremely difficult owing to the immense dimensions of the planet, and consequently enormous movement of electricity or rate at which electrical energy had to be delivered in order to approximate, even in a remote degree, movements or rates which are manifestly attained in the displays of electrical forces in nature and which seemed at first unrealizable by any human agencies; but by gradual and continuous improvements of a generator of electrical oscillations, which I have described in my Patents Nos. 645,576 and 649,621, I finally succeeded in reaching electrical movements or rates of delivery of electrical energy not only approximating, but, as shown in many comparative tests and measurements, actually surpassing those of lightning discharges, and by means of this apparatus I have found it possible to reproduce whenever desired phenomena in the earth the same as or similar to those due to such discharges. With the knowledge of the phenomena discovered by me and the means at command for accomplishing these results I am enabled not only to carry out many operations by the use of known instruments, but also to offer a solution for many important problems

involving the operation or control of remote devices which for want of this knowledge and the absence of these means have heretofore been entirely impossible. For example, by the use of such a generator of stationary waves and receiving apparatus properly placed and adjusted in any other locality, however remote, it is practicable to transmit intelligible signals or to control or actuate at will any one or all of such apparatus for many other important and valuable purposes, as for indicating wherever desired the correct time of an observatory or for ascertaining the relative position of a body or distance of the same with reference to a given point or for determining the course of a moving object, such as a vessel at sea, the distance traversed by the same or its speed, or for producing many other useful effects at a distance dependent on the intensity, wave length, direction or velocity of movement, or other feature or property of disturbances of this character.

在我为了研究闪电放电对地球的电条件的影响而进行的某些研究的过程中,我观察到被布置成能够响应由放电产生的电扰动的灵敏接收仪器有时在它们应该响应的时候没有响应,在调查这种意想不到的行为的原因时,我发现这是由于闪电放电在地球上产生的电波的特性,闪电放电拥有的节点区域能在确定的距离处跟随扰动的正在移动的来源。从这些波的最大值和最小值的大量观察中获得的数据,我发现它们的长度大约从 25 公里到 70 公里不等,这些结果和某些理论推导使我得出这样的结论:这种波可以在全球的所有方向上传播,它们可以有更广泛的不同长度,极端限制是由地球的物理尺寸和性质所施加的。认识到这些波的存在是一个明确无误的证据,表明所产生的扰动已经从它们的起源传导到地球上最偏远的地方,并在那里反映出来,我构思了通过人工工具在地球上产生这样的波的想法,是将它们用于它们适用或可能适用的许多有用目的。由于地球的巨大尺寸,因此这个问题变得极其困难,因此必须以巨大的电力运动或电能输送速率来接近,即使在遥远的程度上,运动或速率也明显达到自然界中的电力的表现,起初似乎任何人类的机械装置都无法实现;但是通过逐渐和持续地改进一个电振荡发生器,这在我的专利 645,576 和 649,621 中描述了这一点,我最终成功地达到了所需的电运动或电能传输速率,不仅接近,而且正如许多比较测试和测量所显示的那样,实际上超过了闪电放电,并且通过这个装置的方法,我发现在任何时候都可以重现与这种放电引起的在地球上的现象相同或相似的预期现象。有了我发现的现象的知识和实现这些结果的方法,我不仅能够通过使用已知的仪器进行许多操作,而且能够为许多涉及远程设备的操作或控制的重要问题提供解决方案,由于这种知识和工具的缺乏,操作或控制远程设备迄今为止是完全不可能的。例如,通过使用这种静态波发生器和在任何其他地方适当放置和调整的接收装置,无论多远,都可以传送可理解的信号或随意控制或启动任何一个或所有这种装置,用于许多其他重要和有价值的目的,用于在任何需要的地方,指示天文台的正确时间,或用于确定物体的相对位置或物体相对于给定点的距离,或用于确定运动物体的路线,例如海上的船只,其经过的距离或其速度,或用于在一定距离上产生许多其他有用的效果,这取决于这种特征的扰动的强度、波长、运动方向或速度、或者其他特征或性质。

I shall typically illustrate the manner of applying my discovery by describing one of the specific uses of the same—namely, the transmission of intelligible signals or messages between distant points—and with this object reference is now made to the accompanying drawings, in which—

我通常会通过描述其特定用途之一来说明应用我的发现的方式——即在远距离点之间传输可理解的信号或消息——为了这个目的,现在参考附图,其中——

Figure 1 represents diagrammatically the generator which produces stationary waves in the earth, and Fig. 2 an apparatus situated in a remote locality for recording the effects of these waves.

图 1 示意性地展示了在地球中产生静态波的发电机, 图 2 展示了位于远处用于记录这些波的影响的装置。

In Fig. 1, A designates a primary coil forming part of a transformer and consisting generally of a few turns of a stout cable of inappreciable resistance, the ends of which are connected to the terminals of a source of powerful electrical oscillations, diagrammatically represented by B. This source is usually a condenser charged to a high potential and discharged in rapid succession through the primary, as in a type of transformer invented by me and now well known; but when it is desired to produce stationary waves of great lengths an alternating dynamo of suitable construction may be used to energize the primary A. C is a spirally-wound secondary coil within the primary having the end nearer to the latter connected to the ground E' and the other end to an elevated terminal E. The physical constants of coil C, determining its period of vibration, are so chosen and adjusted that the secondary system E' C E is in the closest possible resonance with the oscillations impressed upon it by the primary A. It is, moreover, of the greatest importance in order to still further enhance the rise of pressure and to increase the electrical movement in the secondary system that its resistance be as small as practicable and its self-induction as large as possible under the conditions imposed. The ground should be made with great care, with the object of reducing its resistance. Instead of being directly grounded, as indicated, the coil C may be joined in series or otherwise to the primary A, in which case the latter will be connected to the plate E'; but be it that none or a part or all of the primary or exciting turns are included in the coil C the total length of the conductor from the ground-plate E' to the elevated terminal E should be equal to one-quarter of the wave length of the electrical disturbance in the system E' C E or else equal to that length multiplied by an odd number. This relation being observed, the terminal E will be made to coincide with the points of maximum pressure in the secondary or excited circuit, and the greatest flow of electricity will take place in the same. In order to magnify the electrical movement in the secondary as much as possible, it is essential that its inductive connection with the primary A should not be very intimate, as in ordinary transformers, but loose, so as to permit free oscillation—that is to say, their mutual induction should be small. The spiral form of coil C secures this advantage, while the turns near the primary A are subjected to a strong inductive action and develop a high initial electromotive force. These adjustments and relations being carefully completed and other constructive features indicated rigorously observed, the electrical movement produced in the secondary system by the inductive action of the primary A will be enormously magnified, the increase being directly proportionate to the inductance and frequency and inversely to the resistance of the secondary system. I have found it practicable to produce in this manner an electrical movement thousands of times greater than the initial—that is, the one impressed upon the secondary by the primary A—and I have thus reached activities or rates of flow of electrical energy in the system E' C E measured by many tens of thousands of horsepower. Such immense movements of electricity give rise to a variety of novel and striking phenomena, among which are those already described. The powerful electrical oscillations in the system E' C E being communicated to the ground cause corresponding vibrations to be propagated to distant parts of the globe, whence they are reflected and by interference with the outgoing vibrations produce stationary waves the crests and hollows of which lie in parallel circles relatively to which the ground-plate E' may be considered to be the pole. Stated otherwise, the terrestrial conductor is thrown into resonance with the oscillations impressed upon it just like a wire. More than this, a number of facts ascertained by me clearly show that the movement of electricity through it follows certain laws with nearly mathematical rigor. For the present it will be sufficient to state that the planet behaves like a perfectly smooth or polished conductor of inappreciable resistance with capacity and self induction

uniformly distributed along the axis of symmetry of wave propagation and transmitting slow electrical oscillations without sensible distortion and attenuation.

在图 1 中, A 表示构成一个变压器的一部分的初级线圈, 通常由几匝电阻很小的粗电缆构成, 电缆的两端连接到一个强电振荡电源的终端上, 该电源用 B 表示。这个电源通常是一个电容器, 被充电到一个高电位, 通过初级线圈快速连续地放电, 就像我发明的一种变压器, 现在已经广为人知; 但是当希望产生大长度的静态波时, 可以使用合适结构的交流发电机来激励初级 A。C 是初级线圈内的一个螺旋缠绕的次级线圈, 靠近初级线圈的一端连接到接地地 E', 另一端连接到升高的终端 E。决定线圈 C 振动周期的物理常数是选择和调整的, 即次级系统 E' C E 尽可能与初级系统 A 施加在它上的振荡共振。此外, 最重要的是, 为了进一步增强电压的上升和增加次级系统中的电运动, 在所施加的条件下, 次级系统的电阻尽可能小, 并且其自感尽可能大。为了减小接地的电阻, 应该非常小心地铺设接地。如图所示, 线圈 C 可以串联或以其他方式连接到初级线圈 A, 而不是直接接地, 在这种情况下, 后者将连接到板 E'; 但是, 如果初级或激励匝圈没有或者一部分或者全部被包含在线圈 C 中, 则从接地板 E' 到高架终端 E 的导体总长度应等于系统 E' C E 中电扰动波长的四分之一, 或者等于该长度乘以一个奇数。观察到这种关系, 终端 E 将与次级或激励电路中的最大压力 (电压) 点重合, 最大的电流将发生在相同的位置。为了尽可能放大次级中的电运动, 它与初级 A 的感应连接不应该像普通变压器那样非常紧密, 而是松散的, 以便允许自由振荡, 也就是说, 它们的互感应该很小。线圈 C 的螺旋形式保证了这一优点, 而靠近初级线圈 A 的匝圈受到强感应作用, 并产生一个高的初始电动势。仔细完成这些调整和关系, 严格观察其他结构特征, 由初级 A 的感应作用在次级系统中产生的电运动将被极大地放大, 这种增强与电感和频率成正比, 与次级系统的电阻成反比。我发现以这种方式产生比初始运动大几千倍的电运动是可行的, 也就是说, 由初级 A 加在次级上的电运动, 这样在系统 E' C E 我就达到了用数万马力来衡量的电能流的活动或速率。电的这种巨大运动产生了各种新奇而惊人的现象, 其中就有已经描述过的现象。系统 E' C E 中强大的电振荡被传送到接地, 导致相应的振动被传播到地球的远处, 从那里它们被反射, 并通过与输出振动相互干涉产生静态波, 静态波的波峰和波谷位于同心的圆中, 相对于这些圆, 接地板 E' 可以被认为是极点。换句话说, 地球上的导体就像一根导线一样, 随着施加在其上的振动而产生共振。不仅如此, 我查明的一些事实清楚地表明, 电流通过地球的运动遵循某些几乎严格的数学定律。就目前而言, 足以说明行星的表现就像一个完美光滑或抛光的导体, 具有不可感知的电阻, 其电容和自感均匀分布在波传播的对称轴上, 并传输缓慢的电振荡而没有明显的失真和衰减。

Besides the above three requirements seem to be essential to the establishment of the resonating condition.

除了上述之外, 建立共振条件似乎有三个必要条件。

First. The earth's diameter passing through the pole should be an odd multiple of the quarter wave length—that is, of the ratio between the velocity of light—and four times the frequency of the currents.

第一, 穿过极点的地球直径应该是四分之一波长的奇数倍——四分之一波长也就是光速与电流频率的四倍之比。

Second. It is necessary to employ oscillations in which the rate of radiation of energy into space in the form of hertzian or electro-magnetic waves is very small. To give an idea, I would say that the frequency

should be smaller than twenty thousand per second, though shorter waves might be practicable. The lowest frequency would appear to be six per second, in which case there will be but one node, at or near the ground-plate, and, paradoxical as it may seem, the effect will increase with the distance and will be greatest in a region diametrically opposite the transmitter. With oscillations still slower the earth, strictly speaking, will not resonate, but simply act as a capacity, and the variation of potential will be more or less uniform over its entire surface.

第二，有必要采用振荡，在这种振荡中，能量以赫兹波或电磁波的形式辐射到空间的比例非常小。举个例子，我认为频率应该小于每秒两万次，尽管更短的波也是可行的。最低频率似乎是每秒六次，在这种情况下，只有一个节点，在接地板上或附近，这似乎是矛盾的，这种影响将随着距离的增加而增加，在发射机的地球直径对置的区域最大。严格地说，由于振荡速度更慢，地球将不会共振，而只是作为一个电容，其整个表面上的电势变化将或多或少是一致的。

Third. The most essential requirement is, however, that irrespective of frequency the wave or wave-train should continue for a certain interval of time, which I have estimated to be not less than one-twelfth or probably 0.08484 of a second and which is taken in passing to and returning from the region diametrically opposite the pole over the earth's surface with a mean velocity of about four hundred and seventy-one thousand two hundred and forty kilometers per second.

第三、然而，也是最基本的要求，不管频率如何，波或波列应该维持一定的时间间隔，我估计不少于十二分之一秒或不少于可能的 0.08484 秒，并且在以大约每秒 471,240 公里的平均速度在地球表面上穿过和从极地对面的区域返回。

The presence of the stationary waves may be detected in many ways. For instance, a circuit may be connected directly or inductively to the ground and to an elevated terminal and tuned to respond more effectively to the oscillations. Another way is to connect a tuned circuit to the ground at two points lying more or less in a meridian passing through the pole E' or, generally stated, to any two points of a different potential.

静态波的存在可以用许多方法检测。例如，一个电路可以直接或感应地连接到接地和高架终端，并被调谐以更有效地响应振荡。另一种方法是将一个调谐电路连接到或多或少处在通过极点 E' 的子午线上的两点的接地处，或者一般来说，连接到不同电位的任意两点。

In Fig. 2 I have shown a device for detecting the presence of the waves such as I have used in a novel method of magnifying feeble effects which I have described in my Patents Nos. 685,953 and 685,955. It consists of a cylinder D, of insulating material, which is moved at a uniform rate of speed by clockwork or other suitable motive power and is provided with two metal rings F F', upon which bear brushes a and a', connected, respectively, to the terminal plates P and P'. From the rings F F' extend narrow metallic segments s and s', which by the rotation of the cylinder D are brought alternately into contact with double brushes b and b', carried by and in contact with conducting-holders h and h', supported in metallic bearings G and G', as shown. The latter are connected to the terminals T and T' of a condenser H, and it should be understood that they are capable of angular displacement as ordinary brush-supports. The object of using two brushes, as b and b', in each of the holders h and h' is to vary at will the duration of the electric contact of the plates P and P' with the terminals T and T', to which

is connected a receiving-circuit including a receiver R and a device d, performing the duty of closing the receiving-circuit at predetermined intervals of time and discharging the stored energy through the receiver. In the present case this device consists of a cylinder made partly of conducting and partly of insulating material e and e', respectively, which is rotated at the desired rate of speed by any suitable means. The conducting part e is in good electrical connection with the shaft S and is provided with tapering segments f f', upon which slides a brush k, supported on a conducting-rod l, capable of longitudinal adjustment in a metallic support m. Another brush, n, is arranged to bear upon the shaft S, and it will be seen that whenever one of the segments f' comes in contact with the brush k the circuit including the receiver R is completed and the condenser discharged through the same. By an adjustment of the speed or rotation of the cylinder d and a displacement of the brush k along the cylinder the circuit may be made to open and close in as rapid succession and remain open or closed during such intervals of time as may be desired. The plates P and P', through which the electrical energy is conveyed to the brushes a and a', may be at a considerable distance from each other in the ground or one in the ground and the other in the air, preferably at some height. If but one plate is connected to earth and the other maintained at an elevation, the location of the apparatus must be determined with reference to the position of the stationary waves established by the generator, the effect evidently being greatest in a maximum and zero in a nodal region. On the other hand, if both plates be connected to earth the points of connection must be selected with reference to the difference of potential which it is desired to secure, the strongest effect being of course obtained when the plates are at a distance equal to half the wave length.

在图 2 中，我已经展示了一种用于检测波的存在装置，例如我在我的专利号为 685,953 和 685,955 的专利中描述的放大微弱效应的新方法中使用的装置。它由绝缘材料制成的一个圆筒 D 组成，该圆筒由发条装置或其它合适的动力以一致的速度转动，并配有两个金属环 F F'，在金属环上分别装有连接到终端板 P 和 P' 的电刷 a 和 a'。如图所示，从环 F F' 延伸出狭窄的金属段 s 和 s'，通过圆筒 D 的旋转，金属段 s 和 s' 交替地与双电刷 b 和 b' 交替接触，双电刷 b 和 b' 被导电支架 h 和 h' 承载并与之接触，后者被支撑在金属轴承 G 和 G' 中。金属轴承 G 和 G' 连接到一个电容器 H 的终端 T 和 T'，应该理解，它们能够像普通电刷支架一样角位移。在每个支架 h 和 h' 中使用两个电刷 b 和 b' 的目的是随意改变板 P 和 P' 与终端 T 和 T' 的电接触持续时间，终端 T 和 T' 连接有包括一个接收器 R 和一个装置 d 的接收电路，以预定的时间间隔执行闭合接收电路的任务，并通过该接收器释放存储的能量。在这种情况下，该装置包括一个圆筒，一部分由导电材料 e 和一部分由绝缘材料 e' 制成，该圆筒通过任何合适的工具以所需的速度旋转。导电部分 e 与轴 S 有良好的电连接，并设有锥形分段 f f'，被支撑在一个导电杆 l 上的电刷 k 在锥形分段上滑动，电刷 k 能够在金属支架 m 中纵向调节另一个电刷 n 被布置成倚靠在轴 S 上，可以看出，每当一个分段 f' 与电刷 k 接触时，包括接收器 R 的电路就接通，电容器通过该电路放电。通过调节圆筒 d 的速度或旋转以及电刷 k 沿滚筒的位移，可以使电路快速连续地断开和闭合，并在所需的时间间隔期间保持断开或闭合。电能通过板 P 和 P' 传送到电刷 a 和 a'，板 P 和 P' 可以在地面上彼此相距相当大的距离，或者一个在地面上，另一个在空中，最好在一定高度上。如果只有一个板连接到接地，另一个保持在一个高度，设备的位置必须确定参考由发电机建立的静态波的位置，这种效应显然在最大值处最大，而在一个节点区为零。另一方面，如果两个板都接地，则连接点必须参照希望确保的电势差来选择，当两块板处于等于半个波长的距离时，当然会获得最强的效果。

In illustration of the operation of the system let it be assumed that alternating electrical impulses from the generator are caused to produce stationary waves in the earth, as above described, and that the

receiving apparatus is properly located with reference to the position of the nodal and ventral regions of the waves. The speed of rotation of the cylinder D is varied until it is made to turn in synchronism with the alternate impulses of the generator, and the position of the brushes b and b' is adjusted by angular displacement or otherwise, so that they are in contact with the segments S and S' during the periods when the impulses are at or near the maximum of their intensity. These requirements being fulfilled, electrical charges of the same sign will be conveyed to each of the terminals of the condenser, and with each fresh impulse it will be charged to a higher potential. The speed of rotation of the cylinder d being adjustable at will, the energy of any number of separate impulses may thus be accumulated in potential form and discharged through the receiver R upon the brush k coming in contact with one of the segments f'. It will be understood that the capacity of the condenser should be such as to allow the storing of a much greater amount of energy than is required for the ordinary operation of the receiver. Since by this method a relatively great amount of energy and in a suitable form may be made available for the operation of a receiver, the latter need not be very sensitive; but when the impulses are very weak or when it is desired to operate a receiver very rapidly any of the well-known sensitive devices capable of responding to very feeble influences may be used in the manner indicated or in other ways. Under the conditions described it is evident that during the continuance of the stationary waves the receiver will be acted upon by current impulses more or less intense, according to its location with reference to the maxima and minima of said waves; but upon interrupting or reducing the flow of the current the stationary waves will disappear or diminish in intensity. Hence a great variety of effects may be produced in a receiver, according to the mode in which the waves are controlled. It is practicable, however, to shift the nodal and ventral regions of the waves at will from the sending-station, as by varying the length of the waves under observance of the above requirements. In this manner the regions of maximum and minimum effect may be made to coincide with any receiving station or stations. By impressing upon the earth two or more oscillations of different wave length a resultant stationary wave may be made to travel slowly over the globe, and thus a great variety of useful effects may be produced. Evidently the course of a vessel may be easily determined without the use of a compass, as by a circuit connected to the earth at two points, for the effect exerted upon the circuit will be greatest when the plates P P' are lying on a meridian passing through ground-plate E' and will be nil when the plates are located at a parallel circle. If the nodal and ventral regions are maintained in fixed positions, the speed of a vessel carrying a receiving apparatus may be exactly computed from observations of the maxima and minima regions successively traversed. This will be understood when it is stated that the projections of all the nodes and loops on the earth's diameter passing through the pole or axis of symmetry of the wave movement are all equal. Hence in any region at the surface the wave length can be ascertained from simple rules of geometry. Conversely, knowing the wave length, the distance from the source can be readily calculated. In like ways the distance of one point from another, the latitude and longitude, the hour, &c., may be determined from the observation of such stationary waves. If several such generators of stationary waves, preferably of different length, were installed in judiciously-selected localities, the entire globe could be subdivided in definite zones of electric activity, and such and other important data could be at once obtained by simple calculation or readings from suitably-graduated instruments. Many other useful applications of my discovery will suggest themselves, and in this respect I do not wish to limit myself. Thus the specific plan herein described of producing the stationary waves might be departed from. For example, the circuit which impresses the powerful oscillations upon the earth might be connected to the latter at two points. In this application I have advanced various improvements in means and methods of producing and utilizing electrical effects which either in connection with my present discovery or independently of the same may be usefully applied.

在该系统操作的说明中，假设来自发电机的交流电脉冲在地球中产生静态波，如上所述，并且接收设备参照波的波节和波腹区域的位置正确定位。圆筒 D 的转速是变化的，直到它与发电机的交变脉冲同步，刷 b 和 b' 的位置通过角位移或其它方式来调节，这样，在脉冲强度达到或接近最大值时，刷 b 和 b' 与分段 S 和 S' 接触。满足了这些要求，相同符号的电荷将被传送到电容器的每个终端，并且随着每个新的脉冲，它将被充电到更高的电势。圆筒 d 的转速可以随意调节，因此，任何数量的独立脉冲的能量可以以电势的形式积累，并在刷子 k 与分段 f 中的一个接触时通过接收器 R 释放。可以理解的是，电容器的容量应该允许储存比接收器的普通操作所需能量多得多的能量。因为通过这种方法，相对大量的能量和适当的形式可以用于一个接收器的操作，所以后者不需要非常敏感；但是当脉冲非常弱或者当希望非常快速地操作一个接收器时，可以以所指示的方式或者以其他方式使用能够对非常微弱的影响做出响应的任何众所周知的敏感设备。在所描述条件下，很明显，在静态波持续期间，根据接收器相对于所述波的最大值和最小值的位置，接收器将受到或强或弱的电流脉冲的作用；但是当中断或减少电流时，静态波将消失或强度减弱。因此，根据控制波的方式，在接收器中可以产生各种各样的效果。然而，通过在遵守上述要求的情况下改变波的长度，从发送站随意移动波的波节和波腹区域是可行的。以这种方式，最大和最小影响的区域可以与任何一个或多个接收站相重合。通过在地球上施加两种或两种以上不同波长的振荡，可以使合成的静态波在地球上缓慢传播，从而可以产生各种各样有用的效应。显然，不使用罗盘就可以很容易地确定船只的航向，例如通过在两点连接到大地的电路，因为当板 P' 位于通过板 E' 的一条子午线上时，施加在电路上的效果将最大的，当板 P' 位于以板 E' 为圆心的一个同心圆上时，电路上的效果为零。如果节点区和腹侧区保持在固定位置，携带接收装置的船只的速度可以从连续经过的最大值区域和最小值区域的观测值精确计算。如果说所有节点和圆环在穿过波运动的对称轴或对称极点的地球直径上的投影都是都相等的，这就可以理解了。因此，在地表的任何区域，波长都可以根据简单的几何规则来确定。反过来，如果知道了波长，就可以很容易地计算出离波源的距离。以类似的方式从一个点到另一个点的距离、纬度和经度、小时等等，可以通过观察这样的静态波来确定。如果几个这样的发电机的静态波，最好是不同的波长，安装在明智选择的地方，整个地球可以被细分在电活动的确定区域，这样和其他重要的数据可以立刻通过简单的计算或从适当的仪器上读数。我的发现的许多其他有用的应用将会出现，在这方面我不想限制自己。因此，这里描述的产生静态波的具体方案可以被偏离。例如，把强有力的振荡施加到地球上的电路可以在两点上与地球相连。在本申请中，我已经提出了产生和利用电效应的工具和方法的各种改进，这些改进或者与我目前的发现有关，或者独立于我的发现，都可以有效地应用。

I desire it to be understood that such novel features as are not herein specifically claimed will form the subjects of subsequent applications.

我希望能被理解的是，本文未特别主张的这些新颖特征将形成后续申请的主题。

What I now claim is—

我现在主张的是—

1. The improvement in the art of transmitting electrical energy to a distance which consists in establishing stationary electrical waves in the earth, as set forth.

1、对向远处传输电能的技术的改进，如前所述，包括在接地中建立了静态电波。

2. The improvement in the art of transmitting electrical energy to a distance which consists in impressing upon the earth electrical oscillations of such character as to produce stationary electrical waves therein, as set forth.

2、对将电能传输到一定距离的技术的改进，包括在地球上施加具有这样特征的电振荡，从而在地球中产生静态电波，如前所述。

3. The improvement in the art of transmitting and utilizing electrical energy which consists in establishing stationary electrical waves in the natural conducting media, and operating thereby one or more receiving devices remote from the source of energy, as set forth.

3、对传输和利用电能技术的改进，包括在自然传导媒介中建立静态电波，并由此操作一个或多个远离能量源的接收装置，如前所述。

4. The improvement in the art of transmitting and utilizing electrical energy which consists in establishing in the natural conducting media, stationary electrical waves of predetermined length and operating thereby one or more receiving devices remote from the source of energy and properly located with respect to the position of such waves, as herein set forth.

4、对传输和利用电能技术的改进，包括在自然传导媒介中建立预定长度的静态电波，并由此操作一个或多个远离能量源以及相对于这种电波的位置正确定位的接收装置，如本文所述。

5. The improvement in the art of transmitting and utilizing electrical energy, which consists in establishing in the natural conducting media, stationary electrical waves, and varying the length of such waves, as herein set forth.

5、对电能传输和利用技术的改进，包括在自然传导媒介中建立静态电波，并改变这种电波的长度，如本文所述。

6. The improvement in the art of transmitting and utilizing electrical energy, which consists in establishing in the natural conducting media stationary electrical waves and shifting the nodal and ventral regions of these waves, as described.

6、对电能传输和利用技术的改进，包括在自然传导媒介中建立静态电波，并移动这些电波的结区和腹区，如上所述。

NIKOLA TESLA.

尼古拉·特斯拉

Witnesses:

M. LAWSON DYER,

BENJAMIN MILLER.

见证人: M.劳森·戴尔、本杰明·米勒。

No. 787,412.

PATENTED APR. 18, 1905.

N. TESLA.
ART OF TRANSMITTING ELECTRICAL ENERGY THROUGH THE NATURAL
MEDIUMS.

APPLICATION FILED MAY 16, 1900. RENEWED JUNE 17, 1902.

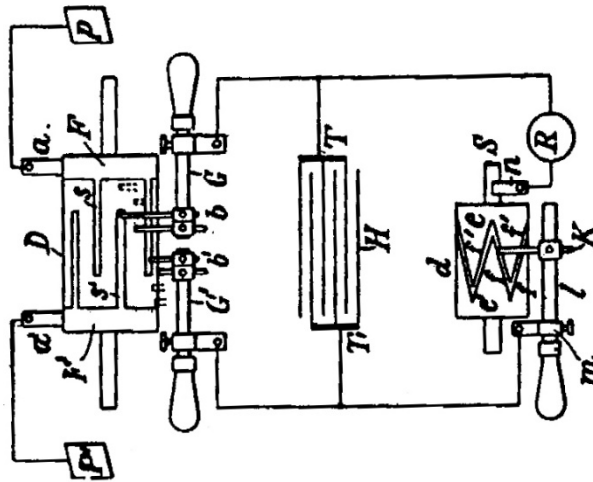


Fig. 2

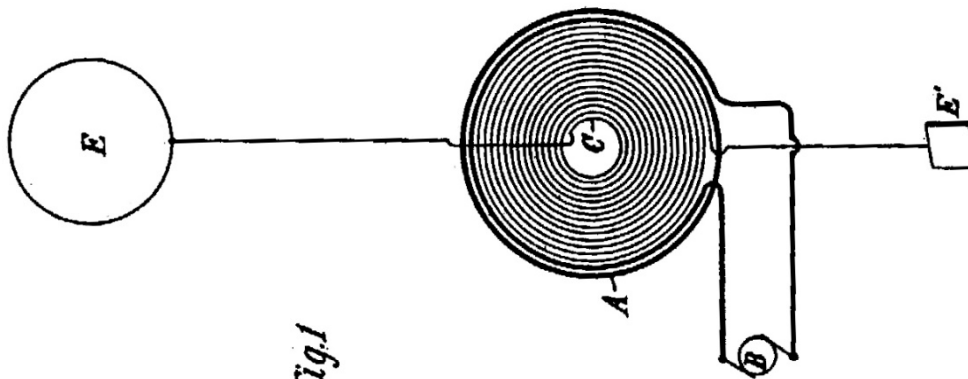


Fig. 1

Witnesses:
Raphael letter
M. Lawson & Co.

Nikola Tesla Inventor
by *Ken. Page & Co.* Attys

APPARATUS FOR THE UTILIZATION OF RADIANT ENERGY.

利用辐射能的装置

NIKOLA TESLA, OF NEW YORK, N. Y.

纽约州纽约市的尼古拉·特斯拉

SPECIFICATION forming part of Letters Patent No. 685,957 dated November 5, 1901.

Application filed March 21, 1901. Serial No. 52,153. (No model.)

该说明书形成了颁发于 1901 年 11 月 5 日编号为 685,957 的专利证书的一部分。

申请于 1901 年 3 月 21 日提交。序列号 52,153。(没有模型)

To all whom it may concern:

致所有相关人士:

Be it known that I, NIKOLA TESLA, a citizen of the United States, residing at the borough of Manhattan, in the city, county, and State of New York, have invented certain new and useful Improvements in Apparatus for the Utilization of Radiant Energy, of which the following is a specification, reference being had to the drawings accompanying and forming a part of the same.

众所周知，我，尼古拉·特斯拉，美国公民，居住在纽约州纽约郡纽约市的曼哈顿区，在用于利用辐射能的装置方面已经发明了一种新的和有用的改进，以下是该发明一个说明书，必须参考随附的图纸，它已形成该说明书的一部分。

It is well known that certain radiations—such as those of ultra-violet light, cathodic, Roentgen rays, or the like—possess the property of charging and discharging conductors of electricity, the discharge being particularly noticeable when the conductor upon which the rays impinge is negatively electrified. These radiations are generally considered to be ether vibrations of extremely small wave lengths, and in explanation of the phenomena noted it has been assumed by some authorities that they ionize or render conducting the atmosphere through which they are propagated. My own experiments and observations, however, lead me to conclusions more in accord with the theory heretofore advanced by me that sources of such radiant energy throw off with great velocity minute particles of matter which are strongly electrified, and therefore capable of charging an electrical conductor, or, even if not so, may at any rate discharge an electrified conductor either by carrying off bodily its charge or otherwise.

众所周知，某些辐射——如紫外光、阴极射线、伦琴射线等——具有使电导体充电和放电的特性，当射线照射的导体带负电时，放电特别明显。这些辐射通常被认为是极小波长的以太振动，在解释注意到的现象时，一些权威人士认为它们使得它们传播所通过的大气电离化或呈现传导性。然而，我自己的实验和观察，使我得出的结论更符合迄今为止我提出的理论，这种辐射能的来源以很大的速度抛出强烈带电的微小的物质粒子，因此能够给电导体充电，

或者,即使不是这样,无论如何都可以通过夺走带电导体的电荷或其他方式使带电导体放电。

My present application is based upon a discovery which I have made that when rays or radiations of the above kind are permitted to fall upon an insulated conducting-body connected to one of the terminals of a condenser while the other terminal of the same is made by independent means to receive or to carry away electricity a current flows into the condenser so long as the insulated body is exposed to the rays, and under the conditions hereinafter specified an indefinite accumulation of electrical energy in the condenser takes place. This energy after a suitable time interval, during which the rays are allowed to act, may manifest itself in a powerful discharge, which may be utilized for the operation or control of mechanical or electrical devices or rendered useful in many other ways.

我目前的申请是基于我的一个发现,即当允许上述类型的射线或辐射落在与电容器的一个终端相连的被绝缘导电体上时,而当电容器的另一个终端由独立的工具制成以接收或带走电力时,只要被绝缘体暴露于射线,一个电流就会流入该电容器,并且在下文指定的条件下,在电容器中发生电能的无限积累。在允许这种射线作用的适当时间间隔之后,这种能量可以在一个强大的放电中表现出来,这种放电可以用于机械或电气设备的操作或控制,或者在许多其他方面变得有用。

In applying my discovery I provide a condenser, preferably of considerable electrostatic capacity, and connect one of its terminals to an insulated metal plate or other conducting-body exposed to the rays or streams of radiant matter. It is very important, particularly in view of the fact that electrical energy is generally supplied at a very slow rate to the condenser, to construct the same with the greatest care. I use, by preference, the best quality of mica as dielectric, taking every possible precaution in insulating the armatures, so that the instrument may withstand great electrical pressures without leaking and may leave no perceptible electrification when discharging instantaneously. In practice I have found that the best results are obtained with condensers treated in the manner described in a patent granted to me February 23, 1897, No. 577,671. Obviously the above precautions should be the more rigorously observed the slower the rate of charging and the smaller the time interval during which the energy is allowed to accumulate in the condenser. The insulated plate or conducting-body should present as large a surface as practicable to the rays or streams of matter, I having ascertained that the amount of energy conveyed to it per unit of time is under otherwise identical conditions proportionate to the area exposed, or nearly so. Furthermore, the surface should be clean and preferably highly polished or amalgamated. The second terminal or armature of the condenser may be connected to one of the poles of a battery or other source of electricity or to any conducting body or object whatever of such properties or so conditioned that by its means electricity of the required sign will be supplied to the terminal. A simple way of supplying positive or negative electricity to the terminal is to connect the same either to an insulated conductor supported at some height in the atmosphere or to a grounded conductor, the former, as is well known, furnishing positive and the latter negative electricity. As the rays or supposed streams of matter generally convey a positive charge to the first condenser-terminal, which is connected to the plate or conductor above mentioned, I usually connect the second terminal of the condenser to the ground, this being the most convenient way of obtaining negative electricity, dispensing with the necessity of providing an artificial source. In order to utilize for any useful purpose the energy accumulated in the condenser, I furthermore connect to the terminals of the same a circuit including an instrument or apparatus which it is desired to operate and another instrument or device for alternately closing and opening the circuit. This latter may be any form of circuit-controller, with fixed

or movable parts or electrodes, which may be actuated either by the stored energy or by independent means.

在应用我的发现时我提供一个电容器，最好有相当大的静电容量，并将其终端中的一个连接到一块被绝缘的金属板或其他暴露在射线或辐射物质流的导体上。非常重要，特别是考虑到电能通常以非常低的速度提供给该电容器，要以最谨慎的方式构造它。我优先使用质量最好的云母作为电介质，在绝缘电容器板时采取一切可能的预防措施，这样仪器就可以承受很大的电压而不会漏电，并且在瞬间放电时不会留下可察觉的带电现象。在实践中，我发现用在 1897 年 2 月 23 日授予我的第 577,671 号专利中描述的方式处理的电容器获得了最佳结果。显然，应更加严格地遵守上述预防措施，充电速度越慢，允许能量在电容器中积聚的时间间隔期间就越短。绝缘板或导体应具有尽可能大的表面以接收射线或物质流，我已确定在每单位时间传递给它的能量在其他相同条件下与暴露面积成正比，或几乎如此。此外，表面应该是干净的，最好高度抛光或由部分结合成整体。电容器的第二个终端或电容器板可以连接到电池或其他电源的电极之一上，或者连接到任何导体或物体上，无论这些导体或物体的性质或状态如何，都可以通过它的工具向该终端提供所需符号的电力。向终端提供正电或负电的一种简单方法是将其连接到被支撑在大气中某一高度的一个被绝缘导体或一个接地导体上，众所周知，前者提供正电，后者提供负电。由于射线或假设的物质流通常将正电荷传输到电容器的第一终端，该终端连接到上述的板或导体，我通常将电容器的第二终端连接到接地，这是获得负电的最方便的方式，无需提供人工电源。为了将电容器中积累的能量用于任何有用的目的，我还将该电容器的两个终端接入了一个电路，该电路包括一个需要操作的仪器或装置和另一个用于交替闭合和断开电路的仪器或装置。后者可以是任何形式的电路控制器，具有固定的或可移动的部件或电极，它们可以由储存的能量或独立的工具驱动。

My discovery will be more fully understood from the following description and annexed drawings, to which reference is now made, and in which—

我的发现将从以下描述和附图中得到更充分的理解，现在参考这些描述和附图，其中—

Figure 1 is a diagram showing the general arrangement of apparatus a usually employed. Fig. 2 is a similar diagram illustrating more in detail typical forms of the devices or elements used in practice, and Figs. 3 and 4 are diagrammatical representations of modified arrangements suitable for special purposes.

图 1 是示出通常采用的装置 a 的总体布置的示意图。图 2 是一个更详细地展示了在实践中使用的设备或组件的典型形式的类似示意图，以及图 3 和 4 是适合于特殊目的的改进布置的图解表示。

As illustrative of the manner in which the several parts or elements of the apparatus in one of its simplest forms are to be arranged and connected for useful operation, reference is made to Fig. 1, in which C is the condenser, P the insulated plate or conducting-body which is exposed to the rays, and P' another plate or conductor which is grounded, all being joined in series, as shown. The terminals T T' of the condenser are also connected to a circuit which includes a device R to be operated and a circuit-controlling device d of the character above referred to.

作为该装置的几个部分或组件的一种最简单形式的布置和连接方式的说明，参见图 1，其中 C 是电容器，P 是暴露于射线下的被绝缘的板或导体，而 P' 是接地的另一个板或导体，所有

这些都串联连接，如图所示。电容器的终端 'T'T' 还连接到一个电路，该电路包括一个待操作的装置 R 和一个具有上述特征的电路控制装置 d。

The apparatus being arranged as shown, it will be found that when the radiations of the sun or of any other source capable of producing the effects before described fall upon the plate P an accumulation of electrical energy in the condenser C will result. This phenomenon, I believe, is best explained as follows: The sun, as well as other sources of radiant energy, throws off minute particles of matter positively electrified, which, impinging upon the plate P, communicate continuously an electrical charge to the same. The opposite terminal of the condenser being connected to the ground, which may be considered as a vast reservoir of negative electricity, a feeble current flows continuously into the condenser, and inasmuch as these supposed particles are of an inconceivably small radius or curvature, and consequently charged to a relatively very high potential, this charging of the condenser may continue, as I have actually observed, almost indefinitely, even to the point of rupturing the dielectric. If the device d be of such character that it will operate to close the circuit in which it is included when the potential in the condenser has reached a certain magnitude, the accumulated charge will pass through the circuit, which also includes the receiver R, and operate the latter.

如图所示布置该装置，将会发现，当太阳辐射或能够产生上述效果的任何其它辐射源的辐射落在板 P 上时，将会导致电能在电容器 C 中积聚。我认为，这种现象的最佳解释如下：太阳，以及其他辐射能量的来源，抛出带正电的微小的物质粒子，这些粒子撞击在板 P 上，连续不断地将电荷传递给它。电容器的另一端连接到大地上，大地可以被认为是一个巨大的负电能的水库，一个微弱的电流连续不断地流入电容器，因为这些假设的粒子具有不可思议的小半径或曲率，因此充电到一个相对非常高的电势，电容器的充电可能会继续，正如我实际观察到的，几乎无限期地进行，甚至达到使电介质被击穿的程度。如果装置 d 具有这样的特性，即当电容器中的电势达到一定值时，它将闭合包含它的电路，则积累的电荷将通过也包含了接收器 R 的电路，并操作后者。

In illustration of a particular form of apparatus which may be used in carrying out my discovery I now refer to Fig. 2. In this figure, which in the general arrangement of the elements is identical to Fig. 1, the device d is shown as composed of two very thin conducting-plates $t\ t'$, placed in close proximity and very mobile, either by reason of extreme flexibility or owing to the character of their support. To improve their action, they should be enclosed in a receptacle, from which the air may be exhausted. The plates $t\ t'$ are connected in series with a working circuit, including a suitable receiver, which in this case is shown as consisting of an electromagnet M, a movable armature a, a retractile spring b, and a ratchet-wheel w, provided with a spring-pawl r, which is pivoted to armature a, as illustrated. When the radiations of the sun or other radiant source fall upon plate P, a current flows into the condenser, as above explained, until the potential therein rises sufficiently to attract and bring into contact the two plates $t\ t'$, and thereby close the circuit connected to the two condenser-terminals. This permits a flow of current which energizes the magnet M, causing it to draw down the armature a and impart a partial rotation to the ratchet-wheel w. As the current ceases the armature is retracted by the spring b, without, however, moving the wheel w. With the stoppage of the current the plates $t\ t'$ cease to be attracted and separate, thus restoring the circuit to its original condition.

为了说明可用于执行我的发现的特定形式的装置，我现在参考图 2。在该图中，组件的总体布置与图 1 相同，装置 d 显示为由两个非常薄的导电板 $t\ t'$ 组成，这两个导电板非常靠近地

放置并且非常容易移动，这或者是由于极度的灵活性，或者是由于它们的支撑的特性。为了提高它们的作用，应该把它们密封在一个容器里，空气就可以从该容器被抽出。板 $t\ t'$ 与包括合适的接收器的工作电路串联连接，在这种情况下，接收器被展示为由电磁体 M 、一个可移动衔铁 a 、一个可伸缩弹簧 b 和棘轮 w 组成，棘轮 w 配有弹簧爪 r ，它被枢接到衔铁 a ，如图所示。当太阳或其他辐射源的辐射落在板 P 上时，如上所述，电流流入电容器，直到其中的电势上升到足以吸引并接触两个板 $t\ t'$ ，从而闭合连接到两个电容器终端的电路。这允许电流的流动，该电流激励磁体 M ，使其拉下衔铁 a 并使棘轮 w 部分地旋转。当电流停止时，衔铁被弹簧 b 缩回，然而，棘轮 w 没有转动。随着电流的停止，板 $t\ t'$ 停止相互吸引和相互分离，从而将电路恢复到其原始状态。

Fig. 3 shows a modified form of apparatus used in connection with an artificial source of radiant energy, which in this instance may be an arc emitting copiously ultra-violet rays. A suitable reflector may be provided for concentrating and directing the radiations. A magnet R and circuit-controller d are arranged as in the previous figures; but in the present case the former instead of performing itself the whole work only serves the purpose of alternately opening and closing a local circuit, containing a source of current B and a receiving or translating device D . The controller d , if desired, may consist of two fixed electrodes separated by a minute air-gap or weak dielectric film, which breaks down more or less suddenly when a definite difference of potential is reached at the terminals of the condenser and returns to its original state upon the passage of the discharge.

图 3 展示了与人造辐射能量源结合使用的改进形式的装置，在这种情况下，该辐射能量源可以是发射大量紫外线的电弧。可以提供合适的一个反射器来聚集和引导辐射。一个磁体 R 和电路控制器 d 如前面的图中那样布置；但在目前的情况下，前者并没有自行完成整个工作，而是用于交替断开和闭合一个本地电路的目的，该电路包含一个电流源 B 和一个接收或转换设备 D 。如果需要，控制器 d 可以由两个固定电极组成，这两个电极由一个微小的空气间隙或弱介电膜隔开，当在电容器的终端处达到确定的电势差时，这两个电极或多或少突然击穿，并在放电通过时恢复到其原始状态。

Still another modification is shown in Fig. 4, in which the source S of radiant energy is a special form of Roentgen tube devised by me, having one terminal k , generally of aluminum, in the form of half a sphere, with a plain polished surface on the front side, from which the streams are thrown off. It may be excited by attaching it to one of the terminals of any generator of sufficiently high electromotive force; but whatever apparatus be used it is important that the tube be exhausted to a high degree, as otherwise it might prove entirely ineffective. The working or discharge circuit connected to the terminals $T\ T'$ of the condenser includes in this case the primary p of a transformer and a circuit-controller comprising a fixed terminal or brush t and a movable terminal t' in the shape of a wheel, with conducting and insulating segments, which may be rotated at an arbitrary speed by any suitable means. In inductive relation to the primary wire or coil p is a secondary s , usually of a much greater number of turns, to the ends of which is connected a receiver R . The terminals of the condenser being connected, as indicated, one to an insulated plate P and the other to a grounded plate P' , when the tube S is excited rays or streams of matter are emitted from the same, which convey a positive charge to the plate P and condenser-terminal T , while terminal T' is continuously receiving negative electricity from the plate P' . This, as before explained, results in an accumulation of electrical energy in the condenser, which goes on as long as the circuit including the primary p is interrupted. Whenever the circuit is closed owing to the rotation of the terminal t' , the stored energy is discharged through the primary p , this giving rise in

the secondary s to induced currents, which operate the receiver R.

图 4 中展示了另一种修改,其中辐射能量源 S 是我设计的特殊形式的伦琴管,具有一个终端 k,通常是铝制,呈半球形,其正面具有平坦的抛光表面,能量流从该表面被抛出。它可以通过连接到任何具有足够高的电动势的发电机的终端之一来激发;但无论使用何种装置,重要的是管子要高度抽尽空气,否则可能会证明完全无效。在这种情况下,连接到电容器的终端 T'T'的工作电路或放电电路包含了一个变压器的初级 p 和一个电路控制器,该电路控制器包括一个固定终端或电刷 t 和一个具有轮子形状的可移动终端 t',该终端具有导电分段和绝缘分段,可以通过任何合适的方式以任意速度旋转。与初级导线或线圈 p 成感应关系的是次级线圈 s,其匝数通常要多得多,其两端连接有接收器 R。如图所示,电容器的终端中的一个连接到绝缘板 P,另一个连接到接地板 P',当管 S 被激励时,射线或物质流从管 S 中发射,将正电荷传送到板 P 和电容器终端 T,而终端 T'连续不断地从板 P'接收负电。如前所述,这会导致电能 在电容器中积累,只要包含了初级 p 的电路被中断,这种情况就会持续下去。每当电路由于终端 t'的旋转而闭合时,存储的能量通过初级线圈 p 释放,这在次级线圈 s 中产生感应电流,该电流操作接收器 R。

It is clear from what has been stated above that if the terminal 'T' is connected to a plate supplying positive instead of negative electricity the rays should convey negative electricity to plate P. The source S may be any form of Roentgen or Lenard tube; but it is obvious from the theory of action that in order to be very effective the electrical impulses exciting it should be wholly or at least preponderatingly of one sign. If ordinary symmetrical alternating currents are employed, provision should be made for allowing the rays to fall upon the plate P only during those periods when they are productive of the desired result. Evidently if the radiations of the source be stopped or intercepted or their intensity varied in any manner, as by periodically interrupting or rhythmically varying the current exciting the source, there will be corresponding changes in the action upon the receiver R, and thus signals may be transmitted and many other useful effects produced. Furthermore, it will be understood that any form of circuit-closer which will respond to or be set in operation when a predetermined amount of energy is stored in the condenser may be used in lieu of the device specifically described with reference to Fig. 2 and also that the special details of construction and arrangement of the several parts of the apparatus may be very greatly varied without departure from the invention.

从以上描述可以清楚地看出,如果终端 T'连接到一个提供正电而不是负电的板上,射线应该将负电传送到板 P 上。来源 S 可以是任何形式的伦琴管或勒纳尔管;但是从作用的理论来看,很明显,为了非常有效,激励它的电脉冲应该完全是一个符号或至少主要是一个符号。如果采用普通的对称交流电,则应采取措施,仅在射线产生所需结果的时期内才允许它们落在板 P 上。显然,如果源头的辐射被停止或拦截,或者它们的强度以任何方式发生变化,例如通过周期性中断或有节奏地改变激励源的电流,在接收器 R 上的作用将有相应的变化,因此信号可以被传输,并产生许多其他有用的效果。此外,可以理解的是,当预定量的能量存储在电容器中时,任何形式的电路闭合器将响应或被设置在运行中,该电路闭合器可以用来代替参照图 2 具体描述的装置,并且该装置的几个部分的结构和布置的具体细节可以在不脱离本发明的情况下可以有很大的变化。

Having described my invention, what I claim is—

描述了我的发明后,我主张—

1. An apparatus for utilizing radiant energy, comprising in combination a condenser, one armature of which is subjected to the action of rays or radiations, independent means for charging the other armature, a circuit and apparatus therein adapted to be operated or controlled by the discharge of the condenser, as set forth.

1、一种利用辐射能的装置，包括一个电容器，该电容器的一个电容板能受到射线或辐射的作用；用于对另一个电容板充电的独立的工具；该装置方法中的一个电路和装置，适于由所述电容器的放电来操作或控制，如上所述。

2. An apparatus for utilizing radiant energy, comprising in combination, a condenser, one armature of which is subjected to the action of rays or radiations, independent means for charging the other armature, a local circuit connected with the condenser-terminals, a circuit-controller therein and means adapted to be operated or controlled by the discharge of the condenser when the local circuit is closed, as set forth.

2、一种利用辐射能的装置，包括一个电容器，该电容器的一个电容板能受到射线或辐射的作用；用于对另一个电容板充电的独立的工具；与该电容器不同终端连接的一个局部电路；该局部电路中的一个电路控制器；以及适于在该局部电路闭合时由电容器的放电操作或控制的工具，如上所述。

3. An apparatus for utilizing radiant energy, comprising in combination, a condenser, one terminal of which is subjected to the action of rays or radiations, independent means for charging the other armature, a local circuit connected with the condenser-terminals, a circuit-controller therein dependent for operation on a given rise of potential in the condenser, and devices operated by the discharge of the condenser when the local circuit is closed, as set forth.

3、一种利用辐射能的装置，包括一个电容器，该电容器的一个终端受到射线或辐射的作用；用于对另一个电容板充电的工具；与该电容器不同终端连接的一个局部电路；该局部电路中的一个电路控制器，它依赖于电容器中给定的一个电势上升而操作；以及当局部电路闭合时由电容器的放电操作的设备，如上所述。

4. An apparatus for utilizing radiant energy, comprising in combination, a condenser, one terminal of which is subjected to the action of rays or radiations, and the other of which is connected with the ground, a circuit and apparatus therein adapted to be operated by the discharge of the accumulated energy in the condenser, as set forth.

4、一种利用辐射能的装置，包括一个电容器，该电容器的一个终端受到射线或辐射的作用；而另一端与接地连接；一个电路和该电路中的装置适于通过释放电容器中积累的能量来操作，如上所述。

5. An apparatus for utilizing radiant energy, comprising in combination, a condenser, one terminal of which is subjected to the action of rays or radiations and the other of which is connected with the ground, a local circuit connected with the condenser-terminals, a circuit-controller therein and means adapted to be operated by the discharge of the condenser when the local circuit is closed, as set forth.

5、一种利用辐射能的装置，包括一个电容器，该电容器的一个终端受到射线或辐射的作用；而另一端与接地连接；与电容器两个终端连接的一个局部电路；该局部电路中的一个电路控制器；以及适于在本地电路闭合时由电容器的放电操作的工具，如上所述。

6. An apparatus for utilizing radiant energy, comprising in combination, a condenser, one terminal of which is subjected to the action of rays or radiations and the other of which is connected with the ground, a local circuit connected with the condenser-terminals, a circuit-controller therein adapted to be operated by a given rise of potential in the condenser, and devices operated by the discharge of the condenser when the local circuit is closed, as set forth.

6、一种利用辐射能的装置，包括一个电容器，该电容器的一个终端受到射线或辐射的作用；而另一端与接地连接；与电容器两个终端连接的一个局部电路；该局部电路中的一个电路控制器，它适于由电容器中给定的一个电位上升来操作；以及当局部电路闭合时由电容器的放电来操作的装置方法，如上所述。

7. An apparatus for utilizing radiant energy, comprising a condenser, having one terminal connected to earth and the other to an elevated conducting-plate, which is adapted to receive the rays from a distant source of radiant energy, a local circuit connected with the condenser-terminals, a receiver therein, and a circuit-controller therefore which is adapted to be operated by a given rise of potential in the condenser, as set forth.

7、一种利用辐射能的装置，包括一个电容器，它的一个终端接地；另一个终端连接到一个高架导电板上，该导电板适于接收来自远处辐射能源的射线；与电容器两个终端连接的一个局部电路；该电路中的一个接收器；一个电路控制器，该电路控制器适于由电容器中给定的电位升高来操作，如上所述。

NIKOLA TESLA.

尼古拉·特斯拉

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N. TESLA.

APPARATUS FOR THE UTILIZATION OF RADIANT ENERGY.

(Application filed Mar. 21, 1901.)

(No Model.)

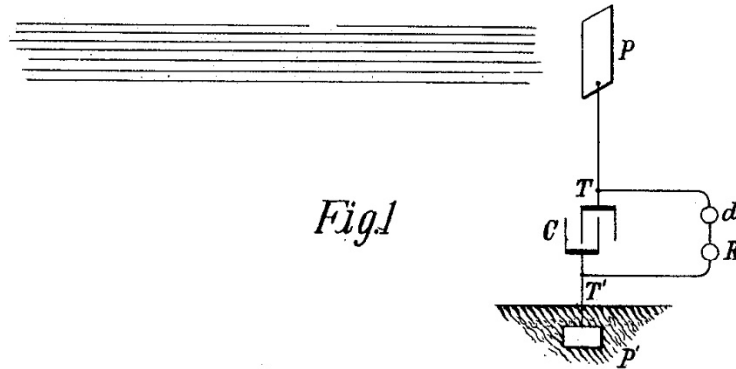


Fig. 1

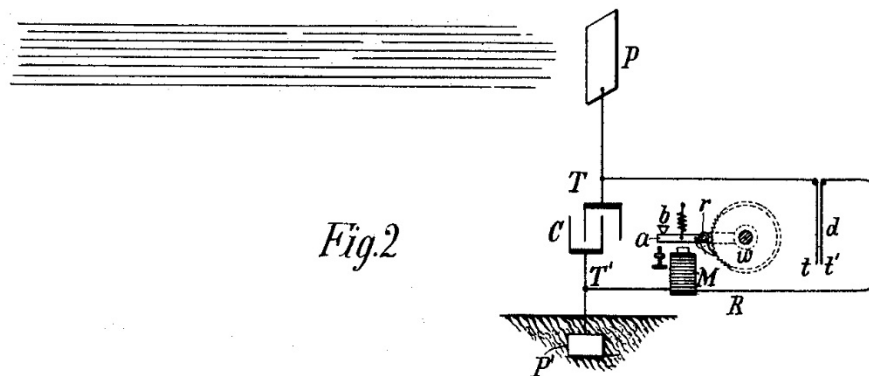


Fig. 2

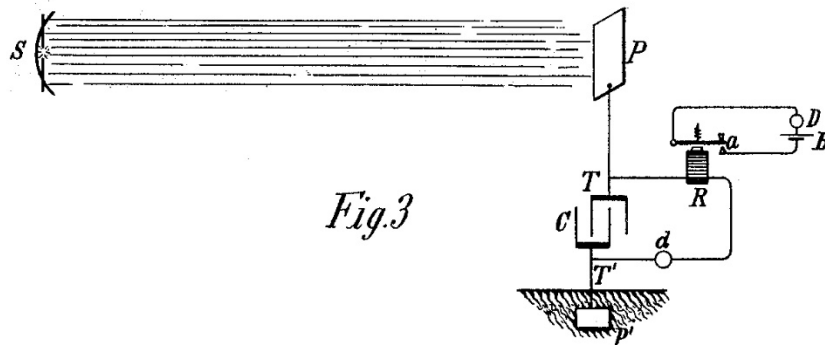


Fig. 3

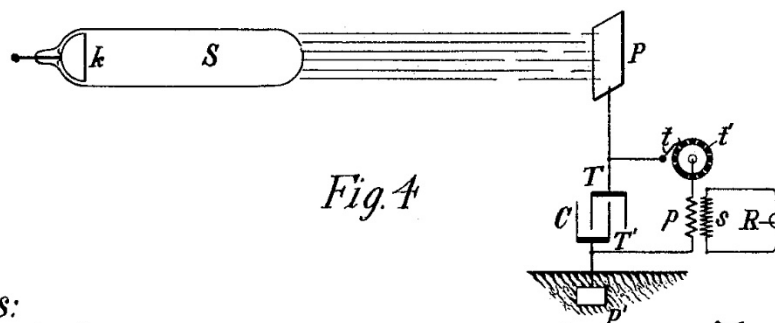


Fig. 4

Witnesses:

Respectfully
M. L. L. L. L. L.

Inventor

Nikola Tesla

by *Ken. Page & Cooper* Att'ys.

METHOD OF UTILIZING RADIANT ENERGY.

利用辐射能的方法

NIKOLA TESLA, OF NEW YORK, N. Y.
纽约州纽约市的尼古拉·特斯拉

SPECIFICATION forming part of Letters Patent No. 685,958 dated November 5, 1901.

Application filed March 21, 1901. Serial No. 52,154. (No model.)

该说明书形成了颁发于 1901 年 11 月 5 日编号为 685,958 的专利证书的一部分。

申请于 1901 年 3 月 21 日提交。序列号 52,154。(没有模型)

To all whom it may concern:

致所有有关人士：

Be it known that I, NIKOLA TESLA, a citizen of the United States, residing at the borough of Manhattan, in the city, county, and State of New York, have invented certain new and useful Improvements in Methods of Utilizing Radiant Energy, of which the following is a specification, reference being had to the drawings accompanying and forming a part of the same.

众所周知，我、尼古拉·特斯拉，一个美国公民，居住在纽约州纽约郡纽约市的曼哈顿区，在利用辐射能方面已经发明了某些新的和有用的改进方法，以下是该发明一个说明书，必须参考随附的参考图纸，它已形成该说明书的一部分。

It is well known that certain radiations—such as those of ultra-violet light, cathodic, Roentgen rays, or the like—possess the property of charging and discharging conductors of electricity, the discharge being particularly noticeable when the conductor upon which the rays impinge is negatively electrified. These radiations are generally considered to be ether vibrations of extremely small wave lengths, and in explanation of the phenomena noted it has been assumed by some authorities that they ionize or render conducting the atmosphere through which they are propagated. My own experiments and observations, however, lead me to conclusions more in accord with the theory heretofore advanced by me that sources of such radiant energy throw off with great velocity minute particles of matter which are strongly electrified, and therefore capable of charging an electrical conductor, or even if not so may at any rate discharge an electrified conductor either by carrying off bodily its charge or otherwise.

众所周知，某些辐射——如紫外光、阴极射线、伦琴射线等——具有使电导体充电和放电的特性，当射线照射的导体带负电时，放电特别明显。这些辐射通常被认为是极小波长的以太振动，在解释注意到的现象时，一些权威人士认为它们使得它们传播通过的大气电离化或呈现传导性。然而，我自己的实验和观察，使我得出的结论更符合迄今为止我提出的理论，这种辐射能的来源以很大的速度抛出强烈带电的微小的物质粒子，因此能够给电导体充电，或者，即使不是这样，无论如何都可以通过夺走带电导体的电荷或其他方式使带电导体放电。

My present application is based upon a discovery which I have made that when rays or radiations of the above kind are permitted to fall upon an insulated conducting body connected to one of the terminals of a condenser, while the other terminal of the same is made by independent means to receive or to carry away electricity, a current flows into the condenser so long as the insulated body is exposed to the rays, and under the conditions hereinafter specified an indefinite accumulation of electrical energy in the condenser takes place. This energy after a suitable time interval, during which the rays are allowed to act, may manifest itself in a powerful discharge, which may be utilized for the operation or control of mechanical or electrical devices or rendered useful in many other ways.

我目前的申请是基于我的一个发现,即当允许上述类型的射线或辐射落在与电容器的一个终端相连的被绝缘导电体上时,而当电容器的另一个终端由独立的工具制成以接收或带走电力时,只要被绝缘体暴露于射线,一个电流就会流入该电容器,并且在下文指定的条件下,在电容器中发生电能的无限积累。在允许这种射线作用的适当时间间隔之后,这种能量可以在一个强大的放电中表现出来,这种放电可以用于机械或电气设备的操作或控制,或者在许多其他方面变得有用。

In applying my discovery I provide a condenser, preferably of considerable electrostatic capacity, and connect one of its terminals to an insulated metal plate or other conducting body exposed to the rays or streams of radiant matter. It is very important, particularly in view of the fact that electrical energy is generally supplied at a very slow rate to the condenser, to construct the same with the greatest care. I use by preference the best quality of mica as dielectric, taking every possible precaution in insulating the armatures, so that the instrument may withstand great electrical pressures without leaking and may leave no perceptible electrification when discharging instantaneously. In practice I have found that the best results are obtained with condensers treated in the manner described in a patent granted to me February 23, 1897, No. 577,671. Obviously the above precautions should be the more rigorously observed the slower the rate of charging and the smaller the time interval during which the energy is allowed to accumulate in the condenser. The insulated plate or conducting body should present as large a surface as practicable to the rays or streams of matter, I having ascertained that the amount of energy conveyed to it per unit of time is under otherwise identical conditions proportionate to the area exposed, or nearly so. Furthermore, the surface should be clean and preferably highly polished or amalgamated. The second terminal or armature of the condenser may be connected to one of the poles of a battery or other source of electricity or to any conducting body or object whatever of such properties or so conditioned that by its means electricity of the required sign will be supplied to the terminal. A simple way of supplying positive or negative electricity to the terminal is to connect the same either to an insulated conductor, supported at some height in the atmosphere, or to a grounded conductor, the former, as is well known, furnishing positive and the latter negative electricity. As the rays or supposed streams of matter generally convey a positive charge to the first condenser-terminal, which is connected to the plate or conductor above mentioned, I usually connect the second terminal of the condenser to the ground, this being the most convenient way of obtaining negative electricity, dispensing with the necessity of providing an artificial source. In order to utilize for any useful purpose the energy accumulated in the condenser, I furthermore connect to the terminals of the same a circuit including an instrument or apparatus which it is desired to operate and another instrument or device for alternately closing and opening the circuit. This latter may be any form of circuit-controller, with fixed or movable parts or electrodes, which may be actuated either by the stored energy or by independent means.

在应用我的发现时我提供一个电容器，最好有相当大的静电容量，并将其终端中的一个连接到一块被绝缘的金属板或其他暴露在射线或辐射物质流的导体上。非常重要的一点是，特别是考虑到电能通常以非常低的速度提供给该电容器，要以最谨慎的方式构造它。我优先使用质量最好的云母作为电介质，在绝缘极片时采取一切可能的预防措施，这样仪器就可以承受很大的电压而不会漏电，并且在瞬间放电时不会留下可察觉的带电现象。在实践中，我发现用在 1897 年 2 月 23 日授予我的第 577,671 号专利中描述的方式处理的电容器获得了最佳结果。显然，应更加严格地遵守上述预防措施，充电速度越慢，允许能量在电容器中积聚的时间间隔就越短。绝缘板或导电体应具有尽可能大的表面以接收射线或物质流，我已确定在每单位时间传递给它的能量在其他相同条件下与暴露面积成正比，或几乎如此。此外，表面应该是干净的，最好高度抛光或由部分结合成整体。电容器的第二个终端或极片可以连接到电池或其他电源的电极之一上，或者连接到任何导体或物体上，无论这些导体或物体的性质或状态如何，都可以通过它的工具向该终端提供所需符号的电力。向终端提供正电或负电的一种简单方法是将其连接到被支撑在大气中某一高度的一个被绝缘导体或一个接地导体上，众所周知，前者提供正电，后者提供负电。由于射线或假设的物质流通常将正电荷传输到电容器的第一终端，该终端连接到上述的板或导体，我通常将电容器的第二终端连接到接地，这是获得负电的最方便的方式，无需提供人工电源。为了将电容器中积累的能量用于任何有用的目的，我还将该电容器的两个终端接入了一个电路，该电路包括一个需要操作的仪器或装置和另一个用于交替闭合和断开电路的仪器或装置。后者可以是任何形式的电路控制器，具有固定的或可移动的部件或电极，它们可以由储存的能量或独立的工具驱动。

The rays or radiations which are to be utilized for the operation of the apparatus above described in general terms may be derived from a natural source, as the sun, or may be artificially produced by such means, for example, as an arc-lamp, a Roentgen tube, and the like, and they may be employed for a great variety of useful purposes.

一般来说，用于上述装置操作的射线或辐射可以来自自然来源，如太阳，或者可以通过诸如弧光灯、伦琴管等装置人工产生，并且它们可以用于各种各样的有用目的。

My discovery will be more fully understood from the following detailed description and annexed drawings, to which reference is now made, and in which—

我的发现将从以下描述和附图中得到更充分的理解，现在参考这些详细的描述和附图，其中

Figure 1 is a diagram showing typical forms of the devices or elements as arranged and connected in applying the method for the operation of a mechanical contrivance or instrument solely by the energy stored; and Fig. 2 is a diagrammatical representation of a modified arrangement suitable for special purposes, with a circuit-controller actuated by independent means.

图 1 是展示了在应用仅通过储存的能量来操作机械装置或仪器的方法中，所布置和连接的设备或组件的典型形式的示意图；以及图 2 是适用于特殊目的的一个改进装置的示意图，该装置具有由独立工具驱动的一个电路控制器。

Referring to Fig. 1, C is the condenser, P the insulated plate or conducting body, which is exposed to the rays, and P' another plate or conductor, all being joined in series, as shown. The terminals T T' of

the condenser are also connected to a circuit including a receiver R, which is to be operated, and a circuit-controlling device d, which in this case is composed of two very thin conducting-plates $t\ t'$, placed in close proximity and very mobile, either by reason of extreme flexibility or owing to the character of their support. To improve their action, they should be enclosed in a receptacle from which the air may be exhausted. The receiver R is shown as consisting of an electromagnet M, a movable armature a, a retractile spring b, and a ratchet-wheel w, provided with a spring-pawl r, which is pivoted to armature a, as illustrated. The apparatus being arranged as shown, it will be found that when the radiations of the sun or of any other source capable of producing the effects before described fall upon the plate P an accumulation of electrical energy in the condenser C will result. This phenomenon, I believe, is best explained as follows: The sun as well as other sources of radiant energy throw off minute particles of matter positively electrified, which, impinging upon the plate P, communicate an electrical charge to the same. The opposite terminal of the condenser being connected to the ground, which may be considered as a vast reservoir of negative electricity, a feeble current flows continuously into the condenser, and inasmuch as these supposed particles are of an inconceivably small radius or curvature, and consequently charged to a relatively very high potential, this charging of the condenser may continue, as I have found in practice, almost indefinitely, even to the point of rupturing the dielectric. Obviously whatever circuit-controller be employed it should operate to close the circuit in which it is included when the potential in the condenser has reached the desired magnitude. Thus in Fig. 2 when the electrical pressure at the terminals $T\ T'$ rises to a certain predetermined value the plates $t\ t'$, attracting each other, close the circuit connected to the terminals. This permits a flow of current which energizes the magnet M, causing it to draw down the armature a and impart a partial rotation to the ratchet-wheel w. As the current ceases the armature is retracted by the spring b without, however, moving the wheel w. With the stoppage of the current the plates $t\ t'$ cease to be attracted and separate, thus restoring the circuit to its original condition.

参照图 1, C 是电容器, P 是暴露于射线下的被绝缘板或导体, 而 P' 是另一个板或导体, 如图所示, 它们都串联在一起。电容器的终端 $T\ T'$ 也连接到一个电路, 该电路包括一个要被操作的接收器 R 和一个电路控制设备 d, 在这种情况下, 该设备由两个非常薄的导电板 $t\ t'$ 组成, 这两个导电板非常靠近地放置并且非常容易移动, 这或者是由于极度的灵活性, 或者是由于它们的支撑的特性。为了提高它们的作用, 应该把它们密封在一个容器里, 空气就可以从该容器被抽出。接收器 R 被展示为包含一个电磁体 M、一个可移动衔铁 a、一个可伸缩弹簧 b 和一个棘轮 w, 棘轮 w 配有弹簧棘爪 r, 如图所示, 棘爪 r 被枢接到衔铁 a。如图所示布置该设备, 将会发现, 当太阳或能够产生上述效果的任何其它辐射源的辐射落在板 P 上时, 将会导致电能电容器 C 中积聚。这种现象, 我认为, 最好的解释如下: 太阳和其他辐射能的来源抛出微小的物质粒子带正电, 碰撞到板 P, 将电荷传递给它。电容器的另一端连接到大地上, 大地可以被认为是一个巨大的负电能的水库, 一个微弱的电流连续不断地流入电容器, 因为这些假设的粒子具有不可思议的小半径或曲率, 因此充电到一个相对非常高的电势, 电容器的充电可能会继续, 正如我实际观察到的, 几乎无限期地进行, 甚至到使电介质击穿的程度。显然, 无论采用哪种电路控制器, 当电容器中的电位达到所需的幅度时, 它都应该闭合包含了它的电路。因此, 在图 2 中, 当终端 $T\ T'$ 处的电压上升到某个预定值时, 板 $t\ t'$ 相互吸引, 闭合了连接到两个终端的电路。这允许电流的一个流动, 该电流激励磁体 M, 使其吸引衔铁 a 并使棘轮 w 部分地旋转。当电流停止时, 衔铁被弹簧 b 拉回, 然而, 棘轮 w 没有转动。随着电流的停止, 板 $t\ t'$ 停止相互吸引和相互分离, 从而将电路恢复到其原始状态。

Many useful applications of this method of utilizing the radiations emanating from the sun or other source and many ways of carrying out the same will at once suggest themselves from the above description. By way of illustration a modified arrangement is shown in Fig. 2, in which the source S of radiant energy is a special form of Roentgen tube devised by me having but one terminal k, generally of aluminum, in the form of half a sphere with a plain polished surface on the front side, from which the streams are thrown off. It may be excited by attaching it to one of the terminals of any generator of sufficiently-high electromotive force; but whatever apparatus be used it is important that the tube be exhausted to a high degree, as otherwise it might prove entirely ineffective. The working or discharge circuit connected to the terminals T T' of the condenser includes in this case the primary p of a transformer and a circuit-controller comprising a fixed terminal or brush t and a movable terminal t' in the shape of a wheel with conducting and insulating segments which may be rotated at an arbitrary speed by any suitable means. In inductive relation to the primary wire or coil p is a secondary s, usually of a much greater number of turns, to the ends of which is connected a receiver R. The terminals of the condenser being connected as indicated, one to an insulated plate P and the other to a grounded plate P', when the tube S is excited rays or streams of matter are emitted from the same, which convey a positive charge to the plate P and condenser-terminal T, while terminal T' is continuously receiving negative electricity from the plate P'. This, as before explained, results in an accumulation of electrical energy in the condenser, which goes on as long as the circuit including the primary p is interrupted. Whenever the circuit is closed, owing to the rotation of the terminal t', the stored energy is discharged through the primary p, this giving rise in the secondary s to induced currents which operate the receiver R.

这种利用从太阳或其他来源发出的辐射的方法的许多有用的应用以及实现这种应用的许多方式将从上述描述中立刻显现出来。作为说明，在图 2 中展示了另一种修改，其中辐射能量源 S 是我设计的特殊形式的伦琴管，具有一个终端 k，通常是铝制，呈半球形，其正面具有平坦的抛光表面，能量流从该表面被抛出。它可以通过连接到任何具有足够高的电动势的发电机的终端之一来激发；但无论使用何种装置，重要的是管子要高度抽尽空气，否则可能会证明完全无效。在这种情况下，连接到电容器的终端 T T' 的工作电路或放电电路包含了一个变压器的初级 p 和一个电路控制器，该电路控制器包括一个固定终端或电刷 t 和一个具有轮子形状的可移动终端 t'，具有导电和绝缘分段，可以通过任何合适的工具以任意速度旋转。与初级导线或线圈 p 成感应关系的是次级线圈 s，其匝数通常要多得多，其两端连接有接收器 R。如图所示，电容器的终端中的一个连接到绝缘板 P，另一个连接到接地板 P'，当管 S 被激励时，射线或物质流从管 S 中发射，将正电荷传送到板 P 和电容器终端 T，而终端 T' 连续不断地从板 P' 接收负电。如前所述，这会导致电能 在电容器中积累，只要包含了初级 p 的电路被中断，这种情况就会持续下去。每当电路由于终端 t' 的旋转而闭合时，存储的能量就会通过初级线圈 p 释放，这在次级线圈 s 中产生感应电流，该电流操作接收器 R。

It is clear from what has been stated above that if the terminal T' is connected to a plate supplying positive instead of negative electricity the rays should convey negative electricity to plate P. The source S may be any form of Roentgen or Lenard tube; but it is obvious from the theory of action that in order to be very effective the electrical impulses exciting it should be wholly or at least preponderatingly of one sign. If ordinary symmetrical alternating currents are employed, provision should be made for allowing the rays to fall upon the plate P only during those periods when they are productive of the desired result. Evidently if the radiations of the source be stopped or intercepted or their intensity varied in any manner, as by periodically interrupting or rhythmically varying the current exciting the source,

there will be corresponding changes in the action upon the receiver R, and thus signals may be transmitted and many other useful effects produced. Furthermore, it will be understood that any form of circuit-closer which will respond to or be set in operation when a predetermined amount of energy is stored in the condenser may be used in lieu of the device specifically described with reference to Fig. 1, and also that the special details of construction and arrangement of the several parts of the apparatus may be very greatly varied without departure from the invention.

从以上描述可以清楚地看出，如果终端 T' 连接到一个提供正电而不是负电的板上，射线应该将负电传送到板 P 上。来源 S 可以是任何形式的伦琴管或勒纳尔管；但是从作用的理论来看，很明显，为了非常有效，激励它的电脉冲应该完全是一个符号或至少主要是一个符号。如果采用普通的对称交流电，则应采取措施，仅在射线产生所需结果的时期内才允许它们落在板 P 上。显然，如果源头的辐射被停止或拦截，或者它们的强度以任何方式发生变化，例如通过周期性中断或有节奏地改变激励源的电流，在接收器 R 上的动作将有相应的变化，因此信号可以被传输，并产生许多其他有用的效果。此外，可以理解的是，当预定量的能量存储在电容器中时，任何形式的电路闭合器将响应或被设置在操作中，该电路闭合器可以用来代替参照图 2 具体描述的装置，并且该装置的几个部分的结构和布置的具体细节可以在不脱离本发明的情况下可以有很大的变化。

Having described my invention, what I claim is—

描述了我的发明后，我主张—

1. The method of utilizing radiant energy, which consists in charging one of the armatures of a condenser by rays or radiations, and the other armature by independent means, and discharging the condenser through a suitable receiver, as set forth.

1、一种利用辐射能的方法，包括通过射线或辐射对电容器的一块电容板充电，通过独立的工具对另一个电容板充电，并通过合适的接收器对电容器放电，如上所述。

2. The method of utilizing radiant energy, which consists in simultaneously charging a condenser by means of rays or radiations and an independent source of electrical energy, and discharging the condenser through a suitable receiver, as set forth.

2、一种利用辐射能的方法，包括通过射线或辐射和独立电源同时对一个电容器充电，并通过一个合适的接收器对电容器放电，如上所述。

3. The method of utilizing radiant energy, which consists in charging one of the armatures of a condenser by rays or radiations, and the other by independent means, controlling the action or effect of said rays or radiations and discharging the condenser through a suitable receiver, as set forth.

3、一种利用辐射能的方法，包括通过射线或辐射对电容器的一块电容板充电，通过独立的工具对另一个电容板充电，控制所述射线或辐射的作用或效果，并通过一个合适的接收器对该电容器放电，如上所述。

4. The method of utilizing radiant energy, which consists in charging one of the armatures of a

condenser by rays or radiations and the other by independent means, varying the intensity of the said rays or radiations and periodically discharging the condenser through a suitable receiver, as set forth.

4、一种利用辐射能的方法，包括通过射线或辐射给电容器的一块电容板充电，通过独立的工具给另一个电容板充电，改变所述射线或辐射的强度，并通过一个合适的接收器周期性地让电容器放电，如上所述。

5. The method of utilizing radiant energy, which consists in directing upon an elevated conductor, connected to one of the armatures of a condenser, rays or radiations capable of positively electrifying the same, carrying off electricity from the other armature by connecting the same with the ground, and discharging the accumulated energy through a suitable receiver, as set forth.

5、一种利用辐射能的方法，包括将能够使其带正电的射线或辐射引导到已经连接到电容器的一个电容板的高架导体上，通过将另一个电容板接地从该电容板带走电力，并通过一个合适的接收器释放累积的能量，如上所述。

6. The method of utilizing radiant energy, which consists in charging one of the armatures of a condenser by rays or radiations, and the other by independent means, and effecting by the automatic discharge of the accumulated energy the operation or control of a suitable receiver, as set forth.

6、一种利用辐射能的方法，包括通过射线或辐射对电容器的一个电容板充电，通过独立的工具对另一个电容板充电，并通过自动释放积累的能量来实现对一个合适的接收器的操作或控制，如上所述。

NIKOLA TESLA.

尼古拉·特斯拉

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No. 685,958.

Patented Nov. 5, 1901.

N. TESLA.

METHOD OF UTILIZING RADIANT ENERGY.

(Application filed Mar. 21, 1901.)

(No Model.)

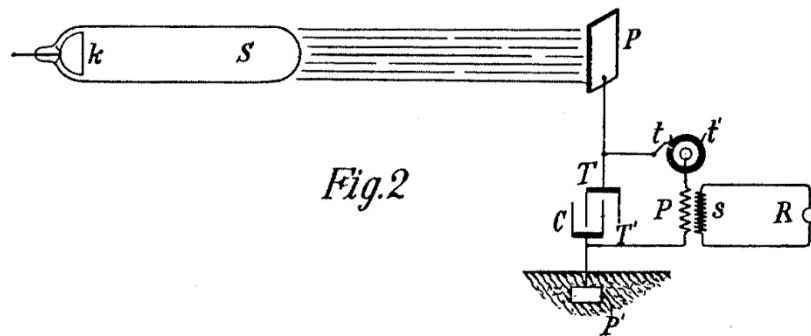
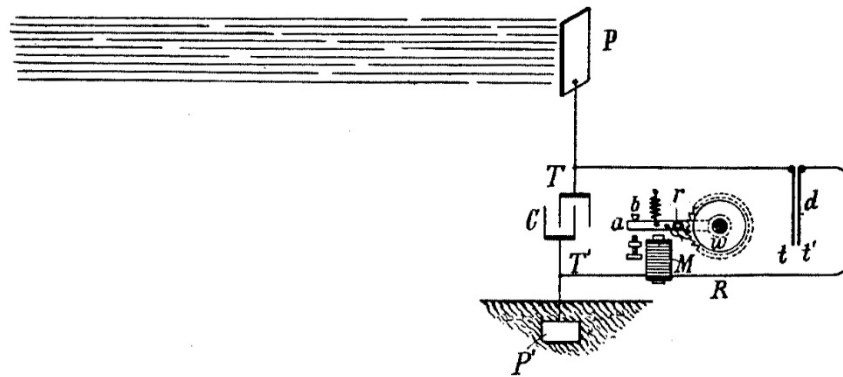


Fig.2

Witnesses:

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FLUID PROPULSION.

流体推进

NIKOLA TESLA, OF NEW YORK, N. Y.

纽约州纽约市的尼古拉·特斯拉

1,061,142. Specification of Letters Patent. Patented May 6, 1913.

Application filed October 21, 1909. Serial No. 523,832.

专利证书说明书第 1,061,142 号。在 1913 年 5 月 6 日被授予专利。

申请于 1909 年 10 月 21 日。序列号为 523,832。

To all whom it may concern:

致所有相关人士：

Be it known that I, NIKOLA TESLA, a citizen of the United States, residing at New York, in the county and State of New York, have invented certain new and useful Improvements in Fluid Propulsion, of which the following is a full, clear, and exact description.

众所周知，我，尼古拉·特斯拉，一位美国公民，居住在纽约州纽约郡纽约市，在流体推进方面已经发明了某些新的和有用的改进，以下是该发明一个完整的、清晰的和准确的描述。

In the practical application of mechanical power based on the use of a fluid as the vehicle of energy, it has been demonstrated that, in order to attain the highest economy, the changes in velocity and direction of the movement of the fluid should be as gradual as possible. In the present forms of such apparatus more or less sudden changes, shocks and vibrations are unavoidable. Besides, the employment of the usual devices for imparting energy to a fluid, as pistons, paddles, vanes and blades, necessarily introduces numerous defects and limitations and adds to the complication, cost of production and maintenance of the machine.

已经证明，在基于使用流体作为能量载体的机械动力的实际应用中，为了获得最高的经济性，流体运动的速度和方向的变化应该尽可能地平缓。在这种装置的现有形式中，或多或少的突然变化、冲击和振动是不可避免的。此外，通常所采用将能量传递给流体的装置，如活塞、桨叶和叶片，必然会引入许多缺陷和限制，并增加机器的复杂性，还增加了机器的生产成本和维护成本。

The object of my present invention is to overcome these deficiencies in apparatus designed for the propulsion of fluids and to effect thereby the transmission and transformation of mechanical energy through the agency of fluids in a more perfect manner, and by means simpler and more economical than those heretofore employed. I accomplish this by causing the propelled fluid to move in natural paths or stream lines of least resistance, free from constraint and disturbance such as occasioned by vanes or kindred devices, and to change its velocity and direction of movement by imperceptible

degrees, thus avoiding the losses due to sudden variations while the fluid is receiving energy.

我的发明旨在以一种更完美的方式和利用比迄今为止所采取措施更简单更有效的措施,通过流体媒介,来克服为推进流体而设计的装置中的这些缺陷并实现机械能的传递和转换。我通过使被推动的流体在最小阻力的自然路径或流线中运动来实现这一点,不受例如由叶片或类似装置引起的约束和干扰,并以无法察觉的程度改变其速度和运动方向,从而避免由于流体在接收能量时由于突然变化而造成的损失。

It is well known that a fluid possesses, among others, two salient properties: adhesion and viscosity. Owing to these a body propelled through such a medium encounters a peculiar impediment known as "lateral" or "skin resistance", which is twofold; one arising from the shock of the fluid against the asperities of the solid substance, the other from internal forces opposing molecular separation. As an inevitable consequence, a certain amount of the fluid is dragged along by the moving body. Conversely, if the body be placed in a fluid in motion, for the same reasons, it is impelled in the direction of movement. These effects, in themselves, are of daily observation, but I believe that I am the first to apply them in a practical and economical manner for imparting energy to or deriving it from a fluid.

众所周知,除了其他特性之外,流体还具有两个最重要的特性:黏滞性和黏附性。由于这些原因,被推动通过一种介质的一个物体会遇到一种称为“侧面阻力”或“表面阻力”的特殊障碍,这是双重的;一个是由流体对固体物质的凹凸不平的粗糙表面进行的冲击所引起的,另一个是由阻止分子分离的内力引起的。一个不可避免的结果是,一定量的流体会被运动的物体拖动。相反,如果把物体放在运动的流体中,出于同样的原因,它会在运动方向上受到推动。这些效应本身是日常观察到的,但我相信我是第一个以一种实用和经济的方式将它们应用于向流体传递能量或从流体中获取能量的人。

The subject of this application is an invention pertaining to the art of imparting energy to fluids, and I shall now proceed to describe its nature and principles of construction of the apparatus which I have devised for carrying it out by reference to the accompanying drawings which illustrate an operative and efficient embodiment of the same.

本申请的主题是与将能量传递给流体的技术相关的一项发明,现在我将参照附图来描述本发明的性质和装置的构造原理,该装置是我为实现本发明而设计的,附图展示了本发明的一个可用且高效的实例。

Figure 1 is a partial end view, and Fig. 2 is a vertical cross section of a pump or compressor constructed and adapted to be operated in accordance with my invention.

图 1 是一个局部端视图,图 2 是一个泵或压缩机的垂直剖面图,该泵或压缩机被构造并适用于根据我的发明进行操作。

In these drawings the device illustrated contains a runner composed of a plurality of flat rigid disks 1 of a suitable diameter, keyed to a shaft 2, and held in position by threaded nut 3, a shoulder 4 and washers 5, of the requisite thickness. Each disk has a number of central openings 6, the solid portions between which form spokes 7, preferably curved, as shown, for the purpose of reducing the loss of energy due to the impact of the fluid. The runner is mounted in a two part volute casing 8, having

stuffing boxes 9, and inlets 10 leading to its central portion. In addition a gradually widening and rounding outlet 11 is provided, formed with a flange for connection to a pipe as usual. The casing 8 rests upon a base 12, shown only in part, and supporting the bearings for the shaft 2, which, being of ordinary construction, are omitted from the drawings.

在这些图中，所示的装置包括由多个具有一个合适直径的扁平刚性圆盘 1 组成的转轮，圆盘 1 被焊接在轴 2 上，并由螺母 3、轴肩 4 和所需厚度的垫圈 5 夹紧到位。每个圆盘具有多个中心开口 6，这些开口之间的实心部分形成轮辐 7，如图所示，轮辐 7 最好是弯曲的，用于减少由于流体冲击造成的能量损失。转轮被安装在由两部分构成的蜗壳 8 中，该蜗壳具有填料函 9 和通向其中心部分的入口 10。此外，提供了逐渐变宽和变圆的出口 11，该出口形成有通常用于连接到管道的一个凸缘。蜗壳 8 被放置在仅被部分地展示的基座 12 上，并支撑轴 2 的轴承，该轴承具有普通结构，已在图中省略。

An understanding of the principle embodied in this device will be gained from the following description of its mode of operation. Power being applied to the shaft and the runner set in rotation in the direction of the solid arrow the fluid by reason of its properties of adherence and viscosity, upon entering through the inlets 10 and coming in contact with the disks 1 is taken hold of by the same and subjected to two forces, one acting tangentially in the direction of rotation, and the other radially outward. The combined effect of these tangential and centrifugal forces is to propel the fluid with continuously increasing velocity in a spiral path until it reaches the outlet 11 from which it is ejected. This spiral movement, free and undisturbed and essentially dependent on the properties of the fluid, permitting it to adjust itself to natural paths or stream lines and to changes its velocity and direction by insensible degrees, is characteristic of this method of propulsion and advantageous in its application. While traversing the chamber enclosing the runner, the particles of the fluid may complete one or more turns, or but a part of one turn. In any given case their path can be closely calculated and graphically represented, but fairly accurate estimate of turns can be obtained simply by determining the number of revolutions required to renew the fluid passing through the chamber and multiplying it by the ratio between the mean speed of the fluid and that of the disks. I have found that the quantity of fluid propelled in this manner is, other conditions being equal, approximately proportionate to the active surface of the runner and to its effective speed. For this reason, the performance of such machine augments at an exceedingly high rate with the increase of their size and speed of revolution.

从下面对其操作模式的描述中可以理解该装置的原理。施加到轴和转轮上的动力使其沿实线箭头的方向旋转，由于流体的黏滞性和黏附性的特性，流体在通过入口 10 进入并与圆盘 1 接触时，被圆盘 1 抓住并受到两个力的作用，一个力沿旋转方向切向作用，另一个力沿辐射方向向外作用。这些切向力和离心力的组合效果是在螺旋路径上以持续增加的速度推动流体，直到它到达出口 11，流体从该出口喷出。这种螺旋运动，自由且不受干扰，并且本质上取决于流体的属性，允许流体调整自己的自然路径或流线，并以不可察觉的程度改变其速度和方向，这是这种推进方法的特点，并在它的应用中具有优势。当流体粒子穿过包围转轮的腔室时，流体粒子可以完成一圈或多圈，或者只是一圈的一部分。在任何给定的情况下，它们的路径可以被精确地计算并以图形表示，但是通过确定用来更新正在穿过腔室的流体所需的圈数，并将该圈数乘以流体的平均速度与圆盘的平均速度的比率，可以获得相当精确的转数估计。我发现，在其他条件相同的情况下，以这种方式被推进的流体的量与转轮的有效表面及其有效速度大致成正比。因此，这种机器的性能随着其尺寸和转速的增加而以极高的速度增长。

The dimensions of the device as a whole, and the spacing of the disks in any given machine will be determined by the conditions and requirements of special cases. It may be stated that the intervening distance should be the greater, the larger the diameter of the disks, the longer the spiral path of the fluid and the greater its viscosity. In general, the spacing should be such that the entire mass of the fluid, before leaving the runner, is accelerated to a nearly uniform velocity, not much below that of the periphery of the disks under normal working conditions and almost equal to it when the outlet is closed and the particles move in concentric circles. It may also be pointed out that such a pump can be made without openings and spokes in the runner, as by using one or more solid disks, each in its own casing, in which form the machine will be eminently adapted for sewage, dredging and the like, when the water is charged with foreign bodies and spokes or vanes especially objectionable.

设备的整体尺寸以及任何给定机器中圆盘的间距将由特殊情况的条件和要求决定。可以说，盘的直径越大，流体的螺旋路径越长，流体黏附性越大，那么圆盘的间隔距离就应该越大。一般来说，该间距应该使得流体的整体物质在离开转轮之前被加速到几乎一致的速度，该速度不能低于正常工作条件下的圆盘外周速度太多，并且当出口关闭并且粒子以同心圆运动时，该速度几乎等于圆盘的外周速度。还可以指出的是，这种泵可以制造成在转轮中没有开口和轮辐，例如通过使用一个或多个实心盘，每个实心盘位于其自身的壳体中，这种形式的机器将非常适用于排污、疏浚和诸如此类，当水中充满异物时，轮辐或叶片尤其令人反感。

Another application of this principle which I have discovered to be not only feasible, but thoroughly practicable and efficient, is the utilization of machines such as above described for the compression or rarefaction of air, or gases in general. In such cases it will be found that most of the general considerations obtaining in the case of liquids, properly interpreted, hold true. When, irrespective of the character of the fluid, considerable pressures are desired, staging or compounding may be resorted to in the usual way the individual runners being, preferably, mounted on the same shaft. It should be added that the same end may be attained with one single runner by suitable deflection of the fluid through rotative or stationary passages.

我已经发现这个原理的另一个应用不仅是可行的，而且是完全适用的和高效的，总的来说，该应用就是利用上述机器来压缩或稀释空气或气体。在这种情况下，将会发现，在液体情况下获得的大多数一般考虑，经过适当的解释，仍然保持正确。不管流体的特性如何，当需要相当大的压力时，可以采用通常的方式进行分级或混合，最好将各个转轮安装在同一轴上。应该补充的是，利用流经旋转通道或静态通道的流体的适当偏转，可以用一个单独的转轮达到相同的目的。

The principles underlying the invention are capable of embodiment also in that field of mechanical engineering which is concerned in the use of fluids as motive agents, for while in some respects the actions in the latter case are directly opposite to those met with in the propulsion of fluids, the fundamental laws applicable in the two cases are the same. In other words, the operation above described is reversible, for if water or air under pressure be admitted to the opening 11 the runner is set in rotation in the direction of the dotted arrow by reason of the peculiar properties of the fluid which traveling in a spiral path and with continuously diminishing velocity, reaches the orifices 6 and 10 through which it is discharged.

构成本发明的基础的原理也能够在涉及使用流体作为驱动剂的机械工程领域中实施，因为在

某些方面，后一种情况下的动作与流体推进中遇到的动作直接相反，在这两种情况下适用的基本定律是相同的。换句话说，上述操作是可逆的，因为如果加压的水或空气被允许进入开口 11，由于流体的特殊性质，转轮被设置成沿虚线箭头的方向旋转，该流体以螺旋路径行进并以连续减小的速度到达孔口 6 和孔口 10 并由此排出。

When apparatus of the general character above described is employed for the transmission of power, however, certain departures from structural similarity between transmitter and receiver may be necessary for securing the best result.

然而，当上述一般特征的设备用于传输动力时，为了确保最佳结果，发射器和接收器之间的结构相似性的某些偏离可能是必要的。

I have, therefore, included that part of my invention which is directly applicable to the use of fluids as motive agents in a separate application filed January 17, 1911, Serial No. 603,049.

因此，我已经在 1911 年 1 月 17 日提交的序列号为 603,049 的单独申请中包含了在我的发明中可直接应用于流体作为驱动剂的部分。

It may be here pointed out, however, as is evident from the above considerations, that when transmitting power from one shaft to another by such machines, any desired ratio between the speeds of rotation may be obtained by proper selection of the diameter of the disks, or by suitably staging the transmitter, the receiver, or both.

然而，这里应该指出的是，从上述考虑中可以明显看出，当采用这种机器将动力从一个轴传递到另一个轴时，两者速度之间的预期转速比可以通过正确选择圆盘的直径来获得，或者通过适当地分级发送器、接收器或分级这两者来获得。

But it may be stated that in one respect, at least, the two machines are essentially different. In the pump, the radial or static pressure, due to centrifugal force, is added to the tangential or dynamic, thus increasing the effective head and assisting in the expulsion of the fluid. In the motor, on the contrary, the first named pressure, being opposed to that of supply, reduces the effective head and velocity of radial flow toward the center. Again, in the propelled machine a great torque is always desirable, this calling for an increased number of disks and smaller distance of separation, while in the propelling machine, for numerous economic reasons, the rotary effort should be the smallest and the speed the greatest practicable. Many other considerations, which will naturally suggest themselves, may affect the design and construction, but the preceding is thought to contain all necessary information in this regard.

但可以说，至少在某一个方面，这两个机器本质上是不同的。在泵中，由于存在离心力，径向压力或静态压力被添加到切向力或动态力上，因此增加了有效压头，并有助于流体的排出。相反，在发动机中，与供给压力对抗的径向压力降低了朝向中心的径向流的有效压头和速度。同样，在被推进的机器中总是需要一个大扭矩，这要求增加圆盘的数量和更小的间隔距离，而在主动推进的机器中，出于多种经济原因，旋转力应该最小的，速度应该是最适用的。许多其他自然会出现的考虑因素可能会影响设计和构造，但上述内容被认为包含了这方面的所有必要信息。

It will be understood that the principles of construction and operation above set forth, are capable of embodiment in machines of the most widely different forms, and adapted for the greatest variety of purposes. In the above, I have sought to describe and explain only the general and typical applications of the principle which I believe I am the first to realize and turn to useful account.

应当理解，上述结构和运行的原理能够在最广泛不同形式的机器中实施，并且适用于最多多样化的目的。在上文中，我只是试图描述和解释原理的一般和典型的应用，我相信我是第一个意识到并转向有用说明的人。

I do not claim in this application the method herein described of imparting energy to a fluid, having made this discovery the subject of a copending application Serial No. 735,914.

我在本申请中没有主张这里描述的将能量传递给流体的方法，这一发现是序列号为 735,914 的待审申请的主题。

What I claim is:

我主张的是：

1. A machine for propelling or imparting energy to fluids comprising in combination a plurality of spaced disks rotatably mounted and having plane surfaces, and enclosing casing, ports of inlet at the central portion of said casing and through which the fluid is adapted to be introduced to the axial portions of the disks, and ports of outlet at the peripheral portion of the casing through which the fluid, when the machine is driven by power, is adapted to be expelled, as set forth.

1、一种用于推进流体或向流体传递能量的机器，包括以下组合：多个被间隔开的圆盘，所述圆盘被安装成可旋转并具有平坦表面；还有封闭的外壳；在所述外壳的中心部分处的入口端口和在外壳的外围部分处的出口端口，流体适于通过所述入口端口被引入圆盘的轴向部分，当机器由动力驱动时，流体适于通过所述出口端口被排出，如前所述。

2. A machine for propelling or imparting energy to fluids, comprising in combination a volute casing provided with ports of inlet and outlet at its central and peripheral portions, respectively, and a runner mounted within the casing and composed of spaced disks with plane surfaces having openings adjacent to the axis of rotation.

2、一种用于推动流体或向流体传递能量的机器，包括以下组合：分别在其中心和外围部分配有入口和出口的一个蜗壳；以及安装在蜗壳内并由具有平面表面的被间隔开的圆盘组成的转轮，这些平面表面具有邻近旋转轴的开口。

3. A rotary pump, comprising in combination a plurality of spaced disks with plane surfaces mounted on a rotatable shaft and provided with openings adjacent thereto, a volute casing enclosing the said disks, means for admitting a fluid into that portion of the casing which contains the shaft and an outlet extending tangentially from the peripheral portion of said casing.

3、一种旋转泵，包括以下组合：多个被间隔开的圆盘，这些具有平坦表面的圆盘被安装在

可旋转轴上的，并配有与轴相邻的开口；一个蜗壳包围所述圆盘；用于允许流体进入包含轴的外壳部分的装置；以及从所述外壳的外周部分切向延伸的一个出口。

In testimony whereof I affix my signature in the presence of two subscribing witnesses.

我在两名见证人在场的情况下签名特此为证。

NIKOLA TESLA.

尼古拉·特斯拉

Witnesses:

M. LAWSON DYER,

DRURY W. COOPER.

见证人:

M.劳森·戴尔、德鲁里·W·库珀。

N. TESLA.
FLUID PROPULSION.
APPLICATION FILED OCT. 21, 1909.

1,061,142.

Patented May 6, 1913.

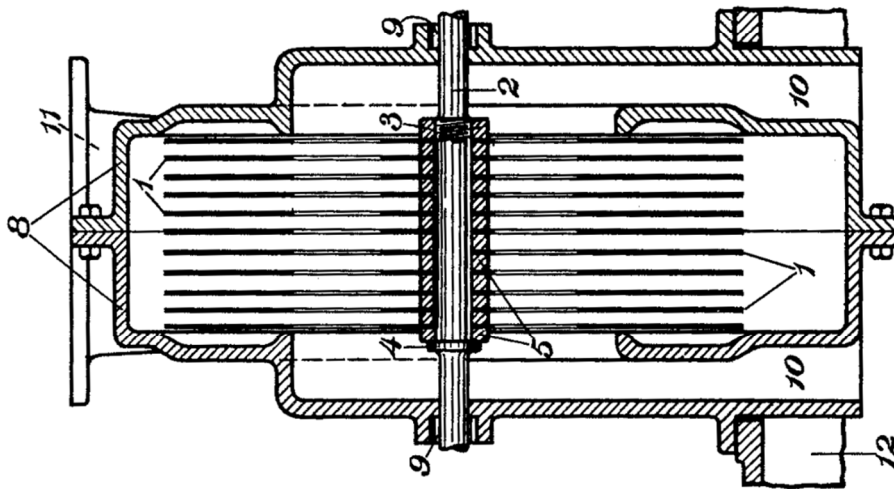


Fig 2

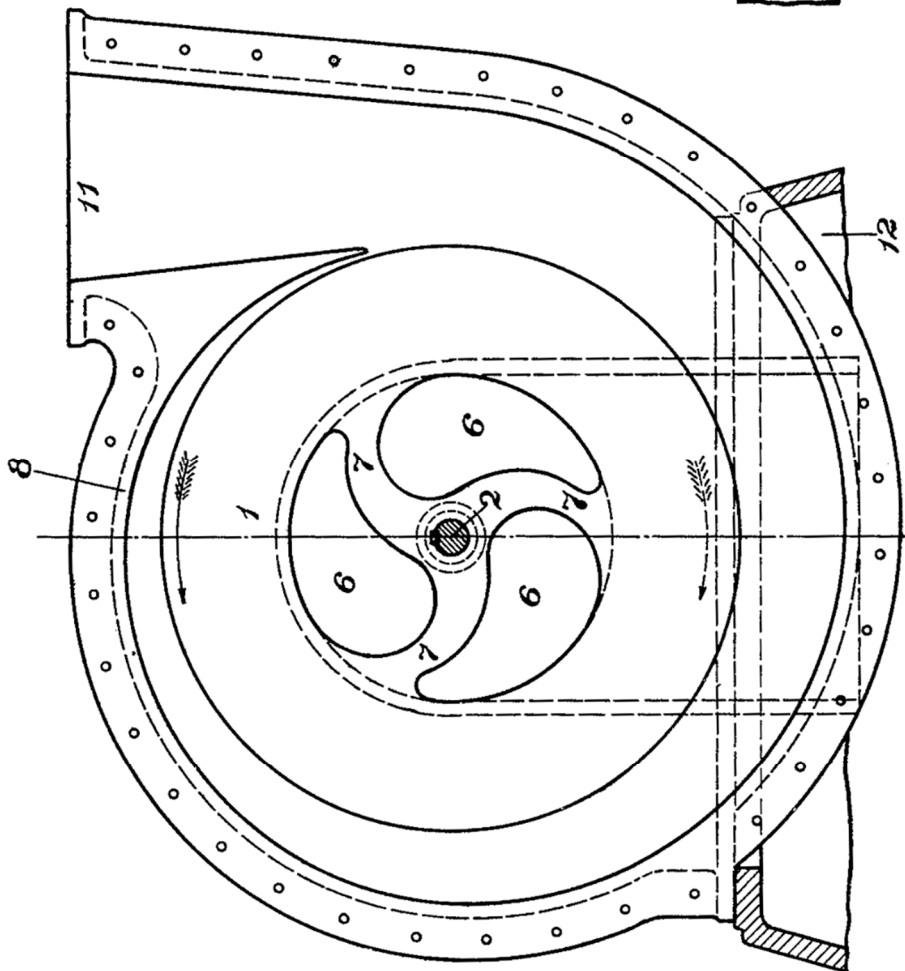


Fig 1

Witnesses:
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Nikola Tesla,
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By his Attorneys
Kerr, Page, Cooper & Hayward

TURBINE.

涡轮机

NIKOLA TESLA, OF NEW YORK, N. Y.

纽约州纽约市的尼古拉·特斯拉

1,061,206. Specification of Letters Patent. Patented May 6, 1913.

Original application filed October 21, 1909, Serial No. 523,832. Divided and this application filed
January 17, 1911. Serial No. 603,049.

专利证书说明书第 1,061,206 号。在 1913 年 5 月 3 日被授予。

原申请于 1909 年 10 月 21 日提交，序列号为 523,832。

在 1911 年 1 月 17 日被分立并提交，序列号为 603,049。

To all whom it may concern:

致所有相关人士：

Be it known that I, NIKOLA TESLA, a citizen of the United States, residing at New York, in the county and State of New York, have invented certain new and useful Improvements in Rotary Engines and Turbines, of which the following is a full, clear, and exact description.

众所周知，我，尼古拉·特斯拉，一位美国公民，居住在纽约州纽约郡纽约市，在旋转发动机和涡轮机方面已经发明了某些新的和有用的改进，以下是该发明一个完整的、清晰的和准确的描述。

In the practical application of mechanical power, based on the use of fluids as the vehicle of energy, it has been demonstrated that, in order to attain the highest economy, the changes in the velocity and direction of movement of the fluid should be as gradual as possible. In the forms of apparatus heretofore devised or proposed, more or less sudden changes, shocks and vibrations are unavoidable. Besides, the employment of the usual devices for imparting to, or deriving energy from a fluid, such as pistons, paddles, vanes and blades, necessarily introduces numerous defects and limitations and adds to the complication, cost of production and maintenance of the machines.

已经证明，在基于使用流体作为能量载体的机械动力的实际应用中，为了获得最高的经济性，流体运动的速度和方向的变化应该尽可能地平缓。在迄今为止设计或提出的设备形式中，或多或少的突然变化、冲击和振动是不可避免的。此外，用于将能量传递给流体或从流体中提取能量的通常设备的采用，如活塞、桨叶和叶片，必然会引入许多缺陷和限制，并增加机器的复杂性，还增加了机器的生产成本和维护成本。

The object of my invention is to overcome these deficiencies and to effect the transmission and transformation of mechanical energy through the agency of fluids in a more perfect manner and by means simpler and more economical than those heretofore employed. I accomplish this by causing the

propelling fluid to move in natural paths or stream lines of least resistance, free from constraint and disturbance such as occasioned by vanes or kindred devices, and to change its velocity and direction of movement by imperceptible degrees, thus avoiding the losses due to sudden variations while the fluid is imparting energy.

我的发明旨在以一种更完美的方式和利用比迄今为止所采用措施更简单更有效的措施,通过流体媒介,来克服这些缺点并实现机械能的传递和转换。我通过使被推动的流体在最小阻力的自然路径或流线中运动来实现这一点,不受例如由叶片或类似装置引起的约束和干扰,并以无法察觉的程度改变其速度和运动方向,从而避免由于流体在传递能量时由于突然变化而造成的损失。

It is well known that a fluid possesses, among others, two salient properties, adhesion and viscosity. Owing to these a solid body propelled through such a medium encounters a peculiar impediment known as "lateral" or "skin resistance," which is twofold, one arising from the shock of the fluid against the asperities of the solid substance, the other from internal forces opposing molecular separation. As an inevitable consequence a certain amount of the fluid is dragged along by the moving body. Conversely, if the body be placed in a fluid in motion, for the same reasons, it is impelled in the direction of movement. These effects, in themselves, are of daily observation, but I believe that I am the first to apply them in a practical and economical manner in the propulsion of fluids or in their use as motive agents.

众所周知,除了其他特性之外,流体还具有两个最重要的特性:黏滞性和黏附性。由于这些原因,被推动通过一种介质的一个固体会遇到一种称为“侧面阻力”或“表面阻力”的特殊障碍,这是双重的,一个是由流体对固体物质的凹凸不平的粗糙表面进行的冲击所引起的,另一个是由阻止分子分离的内力引起的。一个不可避免的结果是,一定量的流体被运动的物体拖动。相反,如果把物体放在运动的流体中,出于同样的原因,它会在运动方向上受到推动。这些效应本身是日常观察到的,但我相信我是第一个以一种实用和经济的方式将它们应用于流体推进或者作为驱动剂的人。

In an application filed by me October 21st, 1909, Serial Number 523,832 of which this case is a division, I have illustrated the principles underlying my discovery as embodied in apparatus designed for the propulsion of fluids. The same principles, however, are capable of embodiment also in that field of mechanical engineering which is concerned in the use of fluids as motive agents, for while in certain respects the operations in the latter case are directly opposite to those met with in the propulsion of fluids, and the means employed may differ in some features, the fundamental laws applicable in the two cases are the same. In other words, the operation is reversible, for if water or air under pressure be admitted to the opening constituting the outlet of a pump or blower as described, the runner is set in rotation by reason of the peculiar properties of the fluid which, in its movement through the device, imparts its energy thereto.

在我于1909年10月21日提交的序列号为523,832的申请中(本申请属于所述申请的一个分立),我已经说明了构成我的发现的基础的原理,具体体现在用于流体推进所设计的装置中。然而,同样的原理也能够机械领域实施,该领域涉及流体作为驱动剂的使用,因为尽管在后一种情况下的操作在某些方面与流体推进中遇到的操作正好相反,且所采用的措施在某些特征上可能不同,但在这两种情况下适用的基本规律是相同的。换句话说,这种操作

是可逆的，因为如果水或空气在压力下被允许进入构成所述的泵或鼓风机的出口，则转轮由于流体的独特性质开始旋转，该流体在它通过该装置的运动中向该装置传递能量。

The present application, which is a division of that referred to, is specially intended to describe and claim my discovery above set forth, so far as it bears on the use of fluids as motive agents, as distinguished from the applications of the same to the propulsion or compression of fluids.

本申请是所提及的申请的一个分立，特别用于描述和主张我的上述发现，就流体作为动力剂的使用而言，有别于将其应用于流体的推进或压缩。

In the drawings, therefore, I have illustrated only the form of apparatus designed for the thermodynamic conversion of energy, a field in which the applications of the principle have the greatest practical value.

因此，在附图中，我仅展示了设计用于热能动力转换的装置形式，在该领域中，该原理的应用具有最大的实用价值。

Figure 1 is a partial end view, and Fig. 2 a vertical cross-section of a rotary engine or turbine, constructed and adapted to be operated in accordance with the principles of my invention.

图 1 是一个旋转发动机或涡轮机的局部端视图，图 2 是它的垂直截面图，该旋转发动机或涡轮机根据本发明的原理进行构造并操作。

The apparatus comprises a runner composed of a plurality of flat rigid disks 13 of suitable diameter, keyed to a shaft 16, and held in position thereon by a threaded nut 11, a shoulder 12, and intermediate washers 17. The disks have openings 14 adjacent to the shaft and spokes 15, which may be substantially straight. For the sake of clearness, but a few disks, with comparatively wide intervening spaces, are illustrated.

该装置包括由多个适合直径的扁平刚性圆盘 13 组成的一个转轮，被榫接在轴 16 上，并通过一个螺母 11、一个轴肩 12 和中间垫圈 17 夹紧到位。圆盘具有邻近轴和轮辐 15 的开口 14，轮辐可以基本上是直的。为了清楚起见，仅展示了几个具有相对较宽的间隔空间的圆盘。

The runner is mounted in a casing comprising two end castings 19, which contain the bearings for the shaft 16, indicated but not shown in detail; stuffing boxes 21 and outlets 20. The end castings are united by a central ring 22, which is bored out to a circle of a slightly larger diameter than that of the disks, and has flanged extensions 23, and inlets 24, into which finished ports or nozzles 25 are inserted. Circular grooves 26 and labyrinth packing 27 are provided on the sides of the runner. Supply pipes 28, with valves 29, are connected to the flanged extensions of the central ring, one of the valves being normally closed.

该转轮被安装在包括两个端板 19 的一个外壳中，该外壳包含用于轴 16 的轴承，该轴承被展示但并不详细；还有填料函 21 和出口 20。不同的端板通过一个中心环 22 结合在一起，该中心环 22 被钻出一个直径略大于圆盘直径的圆，并具有带有凸缘的延伸部 23 和入口 24，成品端口或喷嘴 25 插入到入口 24 中。环形槽 26 和迷宫式密封 27 设置在转轮的侧面。配有阀

29 的供给管 28 连接到中心环的凸缘延伸部, 供给管的一个阀通常是关闭的。

For a more ready and complete understanding of the principle of operation it is of advantage to consider first the actions that take place when the device is used for the propulsion of fluids for which purpose let it be assumed that power is applied to the shaft and the runner set in rotation say in a clockwise direction. Neglecting, for the moment, those features of construction that make for or against the efficiency of the device as a pump, as distinguished from a motor, a fluid, by reason of its properties of adherence and viscosity, upon entering through the inlets 20, and coming in contact with the disks 13, is taken hold of by the latter and subjected to two forces, one acting tangentially in the direction of rotation, and the other radially outward. The combined effect of these tangential and centrifugal forces is to propel the fluid with continuously increasing velocity in a spiral path until it reaches a suitable peripheral outlet from which it is ejected. This spiral movement, free and undisturbed and essentially dependent on the properties of the fluid, permitting it to adjust itself to natural paths or stream lines and to change its velocity and direction by insensible degrees, is a characteristic and essential feature of this principle of operation.

为了更容易和更完整地理解运行原理, 首先考虑当该装置用于推进流体时所发生的作用是有利的, 为此目的, 假设动力被施加到轴上, 并且转轮组以顺时针方向旋转。暂时忽略那些有助于或不利于装置作为泵的效率的结构特征, 这一点与电动机不同, 流体由于其黏滞性和黏附性的属性, 在通过入口 20 进入并与盘 13 接触时, 被盘 13 抓住并受到两个力的作用, 一个力沿旋转方向的切向作用, 另一个力沿径向向外作用。这些切向力和离心力的组合效果是以一个螺旋路径持续增加的速度推动流体, 直到它到达一个适合的外围出口, 并从该出口喷出。这种螺旋运动, 自由且不受干扰, 本质上取决于流体的属性, 允许它调整自己的自然路径或流线, 并以难以察觉的程度改变其速度和方向, 这种螺旋运动是这种运行原理的特有的和必不可少的特征。

While traversing the chamber enclosing the runner, the particles of the fluid may complete one or more turns, or but part of one turn, the path followed being capable of close calculation and graphic representation, but fairly accurate estimates of turns can be obtained simply by determining the number of revolutions required to renew the fluid passing through the chamber and multiplying it by the ratio between the mean speed of the fluid and that of the disks. I have found that the quantity of fluid propelled in this manner, is, other conditions being equal, approximately proportionate to the active surface of the runner and to its effective speed. For this reason, the performance of such machines augments at an exceedingly high rate with the increase of their size and speed of revolution.

当流体粒子穿过包围转轮的腔室时, 流体粒子可以完成一圈或多圈, 或者只是一圈的一部分。在任何给定的情况下, 它们的路径可以被精确地计算并以图形表示, 但是通过确定用来更新正在穿过腔室的流体所需的圈数, 并将该圈数乘以流体的平均速度与圆盘的平均速度的比率, 可以获得相当精确的转数估计。我发现, 在其他条件相同的情况下, 以这种方式被推进的流体的量与转轮的有效表面及其有效速度大致成正比。因此, 这种机器的性能随着其尺寸和转速的增加而以极高的速度增长。

The dimensions of the device as a whole, and the spacing of the disks in any given machine will be determined by the conditions and requirements of special cases. It may be stated that the intervening distance should be the greater, the larger the diameter of the disks, the longer the spiral path of the fluid

and the greater its viscosity. In general, the spacing should be such that the entire mass of the fluid, before leaving the runner, is accelerated to a nearly uniform velocity, not much below that of the periphery of the disks under normal working conditions, and almost equal to it when the outlet is closed and the particles move in concentric circles.

设备的整体尺寸以及任何给定机器中圆盘的间距将由特殊情况的条件和要求决定。可以说, 盘的直径越大, 流体的螺旋路径越长, 流体黏附性越大, 那么圆盘的间隔距离就应该越大。一般来说, 该间距应该使得流体的整体物质在离开转轮之前被加速到几乎一致的速度, 该速度不能低于正常工作条件下的圆盘外周速度太多, 并且当出口关闭并且粒子以同心圆运动时, 该速度几乎等于圆盘的外周速度。

Considering now the converse of the above described operation and assuming that fluid under pressure be allowed to pass through the valve at the side of the solid arrow, the runner will be set in rotation in a clockwise direction, the fluid traveling in a spiral path and with continuously diminishing velocity until it reaches the orifices 14 and 20, through which it is discharged. If the runner be allowed to turn freely, in nearly frictionless bearings, its rim will attain a speed closely approximating the maximum of that of the adjacent fluid and the spiral path of the particles will be comparatively long, consisting of many almost circular turns. If load is put on and the runner slowed down, the motion of the fluid is retarded, the turns are reduced, and the path is shortened.

现在考虑与上述操作相反的情况, 并假设压力下的流体被允许通过实线箭头一侧的阀, 转轮将被设置成沿顺时针方向旋转, 流体以螺旋路径行进并具有持续减小的速度, 直到它到达孔口 14 和 20, 并由此排出。如果允许转轮自由转动, 在几乎无摩擦的轴承中, 其边缘将获得接近邻近流体的最大速度的速度, 并且粒子的螺旋路径将相对较长, 包括许多几乎圆形的转弯。如果加载负载, 转轮减速, 流体的运动就会减速, 转弯就会减少, 路径也会缩短。

Owing to a number of causes affecting the performance, it is difficult to frame a precise rule which would be generally applicable, but it may be stated that within certain limits, and other conditions being the same, the torque is directly proportionate to the square of the velocity of the fluid relatively to the runner and to the effective area of the disks and, inversely, to the distance separating them. The machine will, generally, perform its maximum work when the effective speed of the runner is one-half of that of the fluid; but to attain the highest economy, the relative speed or slip, for any given performance, should be as small as possible. This condition may be to any desired degree approximated by increasing the active area of and reducing the space between the disks.

由于影响性能的多种原因, 很难制定一个普遍适用的精确规则, 但可以说, 在一定范围内, 在其他条件相同的情况下, 转矩与流体相对于转轮的速度的平方成正比, 与圆盘的有效面积成正比, 与圆盘之间的距离成反比。一般来说, 当转轮的有效速度是流体速度的一半时, 机器将做最大功; 但是为了获得最高的经济性, 对于任何给定的性能, 相对速度或转差率应该尽可能小。通过增加盘的有效面积和减小盘之间的空间, 这种情况可以接近任何预期的程度。

When apparatus of the kind described is employed for the transmission of power certain departures from similarity between transmitter and receiver are necessary for securing the best results. It is evident that, when transmitting power from one shaft to another by such machines, any desired ratio between the speeds of rotation may be obtained by a proper selection of the diameters of the disks, or by suitably

staging the transmitter, the receiver or both. But it may be pointed out that in one respect, at least, the two machines are essentially different. In the pump, the radial or static pressure, due to centrifugal force, is added to the tangential or dynamic, thus increasing the effective head and assisting in the expulsion of the fluid. In the motor, on the contrary, the first named pressure, being opposed to that of supply, reduces the effective head and the velocity of radial flow toward the center. Again, in the propelled machine a great torque is always desirable, this calling for an increased number of disks and smaller distance of separation, while in the propelling machine, for numerous economic reasons, the rotary effort should be the smallest and the speed the greatest practicable. Many other considerations, which will naturally suggest themselves, may affect the design and construction, but the preceding is thought to contain all necessary information in this regard.

然而，当上述一般特征的设备用于传输动力时，为了确保最佳结果，发射器和接收器之间的相似性的某些偏离可能是必要的。很明显，当通过这种机器将动力从一个轴传递到另一个轴时，通过适当选择圆盘的直径，或通过适当地分级发送器、接收器或这两者，可以获得任何预期的转速比。但是可以指出，至少在一个方面，这两种机器是本质上不同的。在泵中，由于离心力，径向压力或静态压力被添加到切向力或动态力上，因此增加了有效压头，并有助于流体的排出。相反，在发动机中，与供给压力对抗的径向压力降低了朝向中心的径向流的有效压头和速度。同样，在被推进的机器中总是需要大扭矩，这要求增加圆盘的数量和更小的间隔距离，而在主动推进的机器中，出于多种经济原因，旋转力应该最小，速度应该是最适用的。许多其他自然会出现的考虑因素可能会影响设计和建造，但上述内容被认为包含了这方面的所有必要信息。

In order to bring out a distinctive feature, assume, in the first place, that the motive medium is admitted to the disk chamber through a port, that is a channel which it traverses with nearly uniform velocity. In this case, the machine will operate as a rotary engine, the fluid continuously expanding on its tortuous path to the central outlet. The expansion takes place chiefly along the spiral path, for the spread inward is opposed by the centrifugal force due to the velocity of whirl and by the great resistance to radial exhaust. It is to be observed that the resistance to the passage of the fluid between the plates is, approximately, proportionate to the square of the relative speed, which is maximum in the direction toward the center and equal to the full tangential velocity of the fluid. The path of least resistance, necessarily taken in obedience to a universal law of motion is, virtually, also that of least relative velocity. Next, assume that the fluid is admitted to the disk chamber not through a port, but a diverging nozzle, a device converting wholly or in part, the expansive into velocity-energy. The machine will then work rather like a turbine, absorbing the energy of kinetic momentum of the particles as they whirl, with continuously decreasing speed, to the exhaust.

为了突出区别特征，首先假设运动介质通过端口进入圆盘室，该端口是运动介质以几乎一致的速度穿过的通道。在这种情况下，机器将作为一个旋转发动机运行，流体在其弯曲的路径上持续膨胀到中心出口。膨胀主要沿螺旋路径发生，这是因为向内的扩散受到由于回旋速度所导致由离心力产生的对抗，也受到了对径向排出的巨大阻力的对抗。可以观察到，流体在板之间通过时遇到的阻力大约与相对速度的平方成正比，相对速度在朝向中心的方向上最大，并且等于流体的全切向速度。阻力最小的路径，必然遵循一个普遍的运动规律，实际上也是相对速度最小的路径。接下来，假设流体不是通过一个端口而是通过一个扩张喷嘴进入盘室，扩张喷嘴是将膨胀全部地或部分地转化为速度能的装置。这种机器将会像一个涡轮机一样工作，当粒子以不断降低的速度旋转时，机器吸收粒子的动能用于排出流体。

The above description of the operation, I may add, is suggested by experience and observation, and is advanced merely for the purpose of explanation. The undeniable fact is that the machine does operate, both expansively and impulsively. When the expansion in the nozzles is complete, or nearly so, the fluid pressure in the peripheral clearance space is small; as the nozzle is made less divergent and its section enlarged, the pressure rises, finally approximating that of the supply. But the transition from purely impulsive to expansive action may not be continuous throughout, on account of critical states and conditions and comparatively great variations of pressure may be caused by small changes of nozzle velocity.

我可以补充的是，上述操作的描述是由经验和观察提出的，并且仅仅是为了解释的目的而提出的。不可否认的事实是，机器确实可在可扩张地且有推动力地运转。当喷嘴中的扩张完成或接近完成时，外周余隙空间中的流体压力很小；随着喷嘴变得不那么扩张，并且截面变大，压力上升，最终接近供给压力。但是，由于临界状态和临界条件，从纯脉冲到膨胀作用的转变可能并不总是连续的，而且喷嘴速度的微小变化可能会引起较大的压力变化。

In the preceding it has been assumed that the pressure of supply is constant or continuous, but it will be understood that the operation will be, essentially the same if the pressure be fluctuating or intermittent, as that due to explosions occurring in more or less rapid succession.

在前面已经假设供给压力是恒定的或持续的，但是应该理解，如果压力是波动的或间歇的，运行也将基本上是相同的，因为爆发以或多或少快速连续的方式发生。

A very desirable feature, characteristic of machines constructed and operated in accordance with this invention, is their capability of reversal of rotation. Fig. 1, while illustrative of a special case, may be regarded as typical in this respect. If the right hand valve be shut off and the fluid supplied through the second pipe, the runner is rotated in the direction of the dotted arrow, the operation, and also the performance remaining the same as before, the central ring being bored to a circle with this purpose in view. The same result may be obtained in many other ways by specially designed valves, ports or nozzles for reversing the flow, the description of which is omitted here in the interest of simplicity and clearness. For the same reasons but one operative port or nozzle is illustrated which might be adapted to a volute but does not fit best a circular bore. It will be understood that a number of suitable inlets may be provided around the periphery of the runner to improve the action and that the construction of the machine may be modified in many ways.

根据本发明构造和操作的机器的一个非常令人满意的特征是它们的反转能力。图 1 虽然说明了一种特殊情况，但在这方面可以认为是典型的。如果右手阀被关闭并且通过第二管道供应流体，则转轮在虚线箭头的方向上旋转，操作以及性能仍然与以前相同，考虑到这个目的，中心环被钻出一个圆。通过专门设计的用于逆转流向的阀、端口或喷嘴，可以以许多其他方式获得相同的结果，为了简单和清楚起见，这里省略了对这些方式的描述。出于同样的原因，只展示了一个可使用的端口或喷嘴，它可以适用于蜗壳，但并不最适合圆形钻孔。可以理解的是，可以在转轮的外周设置多个合适的入口来改善动作，并且可以以多种方式修改机器的结构。

Still another valuable and probably unique quality of such motors or prime movers may be described. By proper construction and observance of working conditions the centrifugal pressure, opposing the

passage of the fluid, may, as already indicated, be made nearly equal to the pressure of supply when the machine is running idle. If the inlet section be large, small changes in the speed of revolution will produce great differences in flow which are further enhanced by the concomitant variations in the length of the spiral path. A self-regulating machine is thus obtained bearing a striking resemblance to a direct-current electric motor in this respect that, with great differences of impressed pressure in a wide open channel the flow of the fluid through the same is prevented by virtue of rotation. Since the centrifugal head increases as the square of the revolutions, or even more rapidly, and with modern high grade steel great peripheral velocities are practicable, it is possible to attain that condition in a single stage machine, more readily if the runner be of large diameter. Obviously this problem is facilitated by compounding, as will be understood by those skilled in the art. Irrespective of its bearing on economy, this tendency which is, to a degree, common to motors of the above description, is of special advantage in the operation of large units, as it affords a safeguard against running away and destruction. Besides these, such a prime mover possesses many other advantages, both constructive and operative. It is simple, light and compact, subject to but little wear, cheap and exceptionally easy to manufacture as small clearances and accurate milling work are not essential to good performance. In operation it is reliable, there being no valves, sliding contacts or troublesome vanes. It is almost free of windage, largely independent of nozzle efficiency and suitable for high as well as for low fluid velocities and speeds of revolution.

可以描述这种发动机或原动机的另一个有价值的和可能是独特的品质。如前所述,通过适当的结构和对工作条件的观察,可以使对抗流体穿过腔室的离心压力几乎等于机器空转时的供给压力。如果进气道截面很大,转速的微小变化将产生很大的流量差异,这种差异会因伴随而来的螺旋路径长度的变化而进一步增强。因此,获得了一种自调节机器,在这方面与直流电动机具有惊人的相似性,即,在一个宽阔的敞口通道中具有很大的外加压力差的情况下,流体通过该通道的流动由于旋转而被阻止。由于离心压头随着转数的平方而增加,甚至增加得更快,而且用现代的高级钢,大的圆周速度是可行的,所以有可能在单级机器中达到那个条件,如果转轮直径大,就更容易达到那个条件。显然,正如本领域技术人员所理解的那样,这个问题通过配合变得更容易解决。不考虑其对经济的影响,这种倾向在一定程度上是上述发动机的共同特点,在大型机组的运行中具有特殊的优势,因为它提供了一道防止失控和破坏的保障。除此之外,这种原动机还具有许多其他优点,既有结构上的,又有操作上的。它简单、轻便、紧凑,几乎没有磨损,价格低廉,而且非常容易制造,因为小的间隙和精确的铣削加工对于良好的性能并不是完全必要的。在运行中,它是可靠的,没有阀门、滑动接触或麻烦的叶片。它几乎没有风阻,很大程度上与喷嘴效率无关,适用于高/低流速和高/低转速。

It will be understood that the principles of construction and operation above generally set forth, are capable of embodiment in machines of the most widely different forms, and adapted for the greatest variety of purposes. In my present specification I have sought to describe and explain only the general and typical applications of the principle which I believe I am the first to realize and turn to useful account.

可以理解的是,上面概括阐述的构造的和运行的原理能够在最广泛的不同形式的机器中实施,并且适用于最多种类的目的。在我目前的说明书中,我只试图描述和解释该原理的一般应用和典型应用,我相信我是第一个意识到并转向有用说明的人。

What I claim is:

我主张的是：

1. A machine adapted to be propelled by a fluid consisting in the combination with a casing having inlet and outlet ports at the peripheral and central portions, respectively, of a rotor having plane spaced surfaces between which the fluid may flow in natural spirals and by adhesive and viscous action impart its energy of movement to the rotor, as described.

1、一种适于由流体推进的机器，该机器包括分别在一个转子的外周和中心部分具有入口和出口的外壳，该转子具有被间隔的平坦表面，流体可以在这些表面之间以自然螺旋的方式流动，并且通过黏滯性和黏附性的作用将其运动能量传递给转子，如上所述。

2. A machine adapted to be propelled by a fluid, comprising a rotor composed of a plurality of plane spaced disks mounted on a shaft and open at or near the same, an enclosing casing with a peripheral inlet or inlets, in the plane of the disks, and an outlet or outlets in its central portion, as described.

2、一种适于由流体推进的机器，包括由安装在轴上并在轴旁边或轴附近设有开口的多个被间隔的平面圆盘组成的一个转子；一个封闭外壳，它具有在圆盘平面内的一个或多个外周入口和在其中中心部分的一个或多个出口，如上所述。

3. A rotary engine adapted to be propelled by adhesive and viscous action of a continuously expanding fluid comprising in combination a casing forming a chamber, an inlet or inlets tangential to the periphery of the same, and an outlet or outlets in its central portion, with a rotor composed of spaced disks mounted on a shaft, and open at or near the same, as described.

3、适于由持续膨胀的流体的黏滯性和黏附性的作用来推动的一种旋转发动机，包括形成腔室的壳体；与其外周相切的一个或多个入口；以及在其中中心部分的一个或多个出口；由安装在轴上的被间隔开的圆盘组成的转子，并在轴处或轴附近设有开口，如上所述。

4. A machine adapted to be propelled by fluid, consisting in the combination of a plurality of disks mounted on a shaft and open at or near the same, and an enclosing casing with ports or passages of inlet and outlet at the peripheral and central portions, respectively, the disks being spaced to form passages through which the fluid may flow, under the combined influence of radial and tangential forces, in a natural spiral path from the periphery toward the axis of the disks, and impart its energy of movement to the same by its adhesive and viscous action thereon, as set forth.

4、一种适于由流体推动的机器，包括安装在轴上并在轴旁边或轴附近设有开口的多个圆盘；以及一个封闭外壳，分别在外周和中心部分设有入口和出口的端口或通道；被间隔开的用于形成通道的圆盘，在径向力和切向力的组合影响下，流体可以以自然的螺旋路径从圆盘的外周朝向盘的轴线方向，流过这些通道，并通过其黏滯性和黏附性的作用将其运动能量传递给盘，如上所述。

5. A machine adapted to be propelled by a fluid comprising in combination a plurality of spaced disks rotatably mounted and having plane surfaces, an enclosing casing and ports or passages of inlet and

outlet adjacent to the periphery and center of the disks, respectively, as set forth.

5、一种适于由流体推进的机器，其组合包括多个被间隔开的圆盘，所述圆盘被安装成可旋转并具有平坦表面；一个封闭的外壳以及分别邻近圆盘外周的入口端口/通道和邻近圆盘中心的出口端口/通道，如前所述。

6. A machine adapted to be propelled by a fluid comprising in combination a runner composed of a plurality of disks having plane surfaces and mounted at intervals on a central shaft, and formed with openings near their centers, and means for admitting the propelling fluid into the spaces between the disks at the periphery and discharging it at the center of the same, as set forth.

6、一种适于由流体推进的机器，该机器包括由多个圆盘组成的转轮，这些圆盘具有平坦表面并且被间隔地安装在一个中心轴上，并且在圆盘的中心附近形成有开口，以及用于允许推进流体在外周进入圆盘之间的空间并且在盘的中心排出流体的装置，如前所述。

7. A thermo-dynamic converter, comprising in combination a series of rotatably mounted spaced disks with plane surfaces, an enclosing casing, inlet ports at the peripheral portion and outlet ports leading from the central portion of the same, as set forth.

7、一种热动力转换器，包括一系列可旋转地安装的具有平坦表面的被间隔开的圆盘、一个封闭外壳、在外周部分的入口和从其中心部分引出的出口，如上所述。

8. A thermo-dynamic converter, comprising in combination a series of rotatably mounted spaced disks with plane surfaces and having openings adjacent to their central portions, an enclosing casing, inlet ports in the peripheral portion, and outlet ports leading from the central portion of the same, as set forth.

8、一种热动力转换器，包括一系列被安装成可旋转的被间隔开的圆盘，这些圆盘具有平坦表面并具有邻近其中心部分的开口；一个封闭壳体，在外周部分的入口，以及从其中心部分引出的出口，如上所述。

In testimony whereof I affix my signature in the presence of two subscribing witnesses.

我在两名见证人在场的情况下签名特此为证。

NIKOLA TESLA.

尼古拉·特斯拉

Witnesses:

M. LAWSON DYER,

WM. BOHLEBER.

见证人:

M.劳森·戴尔、WM.波赫伯。

N. TESLA.

TURBINE.

APPLICATION FILED JAN. 17, 1911.

1,061,206.

Patented May 6, 1913.

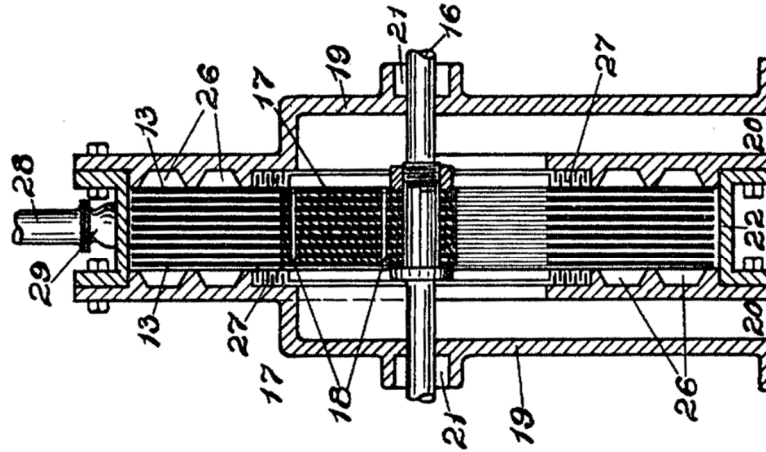


Fig. 2.

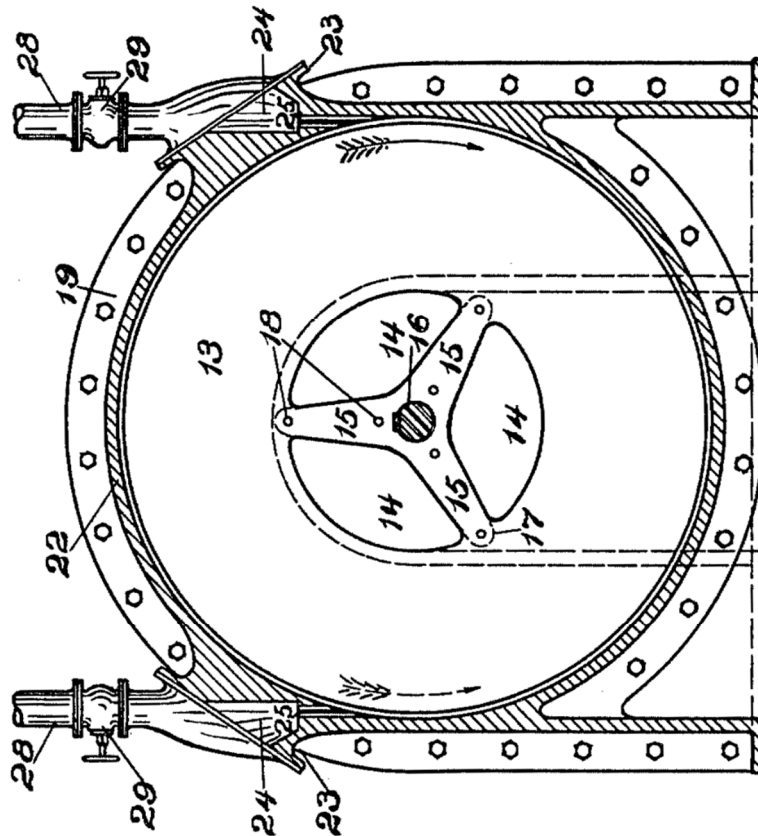


Fig. 1.

Witnesses:
R. Diaz Brito
Wm. C. Kohler

Nikola Tesla, Inventor
By his Attorneys
Ken. Page Cooper & Hayward

FOUNTAIN.

喷泉

NIKOLA TESLA, OF NEW YORK, N. Y.

纽约州纽约市的尼古拉·特斯拉

1,113,716. Specification of Letters Patent. Patented Oct. 13, 1914.

Application filed October 28, 1913. Serial No. 797,718.

专利证书说明书第 1,113,716 号。在 1913 年 10 月 13 日被授予专利。

申请于 1913 年 10 月 28 日。序列号为 797,718。

To all whom it may concern:

致所有相关人士：

Be it known that I, NIKOLA TESLA, a citizen of the United States, residing at New York, borough of Manhattan, county and State of New York, have invented certain new and useful Improvements in Fountains, of which the following is a full, clear, and exact description.

众所周知，我，尼古拉·特斯拉，一位美国公民，居住在纽约州纽约郡纽约市的曼哈顿区，在喷泉方面已经发明了某种新的和有用的改进，以下是该发明一个完整的、清晰的和准确的描述。

It has been customary heretofore in fountains and aquarian displays, to project spouts, jets, or sprays of water from suitable fixtures, chiefly for decorative and beautifying purposes. Invariably, the quantity of the issuing fluid was small and the pleasing impression on the eye was solely the result of the more or less artistic arrangement of the streamlets and ornaments employed. The present invention is a departure from such practice in that it relies principally on the fascinating spectacle of a large mass of fluid in motion and the display of seemingly great power. Incidentally, it permits the realization of beautiful and striking views through illumination and the disposition of voluminous cascades which, moreover, may be applied to useful purposes in ways not practicable with the old and familiar devices. These objects are accomplished by the displacement of a great volume of fluid with a relatively small expenditure of energy in the production and maintenance of a veritable waterfall as distinguished from a mere spout, jet or spray.

迄今为止，在喷泉和水族箱展示中，习惯上从合适的固定装置中喷水、射水或喷雾，主要是为了装饰和美化的目的。不变的是，流出的液体量很少，而令人赏心悦目的印象完全是或多或少的细流和艺术安排装饰品的结果。本发明与这种实践的不同之处在于它主要依赖于大量运动的流体的迷人景象和看似强大的力量展示。顺便说一句，它允许通过照明和人工瀑布的配置来实现美丽和引人注目的景观，此外，它可以以旧和熟悉的设备达不到的方式应用于有用的目的。这些目的是通过以相对较小的能量消耗来排放大量的流体来实现的，以产生和维持真正的瀑布，与仅仅是喷水、射水或喷雾的景观有着明显区别。

The underlying idea of the invention can be carried out by apparatus of widely varied design, but in the present instance the simplest forms, of which I am aware, are shown as embodiments of the principle involved.

本发明的基本思想可以通过各种设计的装置来实现，但是在本实例中，我展示了我所知道的最简单的形式作为所涉及的原理的实例。

In the accompanying drawing, Figure 1 is a top plan and Fig. 2 a vertical central sectional view of an appliance which I have devised for the purpose. Fig. 3 and Fig. 4 illustrate corresponding views of a similar device of much simpler construction.

在附图中，图 1 是我为此目的设计的器具的俯视图，图 2 是该器具的垂直中心剖面图。图 3 和图 4 展示了结构简单得多的类似装置的相应视图。

Referring to the first, 1 represents a receptacle of any suitable material, as metal, glass, porcelain, marble, cement or other compound, with a central hub 2 and a conical conduit 3, flared out at the top and provided with openings 4 at the bottom. In the hub 2 is inserted a shaft 5 rotatably supported on ball bearings 6 and carrying at its lower end a friction pulley or gear wheel 7. To the upper end of the shaft is fastened a casting 8, preferably of some non-corrosive alloy, with blades 9 constituting a screw which is shown in this instance as the best known propelling device; but it will be understood that other means may be employed. A motor 10 is suitably mounted so as to transmit through wheel 11, by friction or otherwise, power to the pulley or wheel 7. Openings 4 may be covered with removable strainers and receptacles 1 may be provided with convenient connections, respectively, for cleaning and renewing the liquid. It is thought unnecessary to show these attachments in the drawing.

参考图 1，1 代表任何适合材料的一个容器，这种材料如金属、玻璃、陶瓷、大理石、水泥或其他化合物，具有一个中心轮毂 2 和一个锥形导管 3，在顶部向外展开，在底部设有开口 4。在轮毂 2 中插入一个轴 5，轴 5 可旋转地被支撑在滚珠轴承 6 上，并且在其下端承载摩擦滑轮或齿轮 7。在轴的上端固定有一个铸件 8，该铸件最好是由某种耐腐蚀合金制成，叶片 9 成为一个螺杆的组成部分，该螺杆在这种情况下被展示为最众所周知的推进装置；但是应当理解，也可以采用其他方式。一个发动机 10 被适当地安装，以便通过摩擦或其他方式将动力通过轮 11 传递到滑轮或轮 7。开口 4 可以用可拆卸的过滤器覆盖，容器 1 可以分别设有方便的连接件，用于清洁和更新液体。认为没有必要在图纸中展示这些附件。

The operation will be readily understood. Receptacle 1 being filled to the proper level with water or other fluid, and the power turned on, the propeller blades 9 are set in rotation and the fluid, drawn through the openings 4, is lifted to the horizontal flared out top of conduit 3 until it overflows in the form of a circular cascade.

运行将很容易理解。用水或其他流体将容器 1 填充到适当的水平，并且打开电源，螺旋桨叶片 9 开始旋转，并且通过开口 4 吸入的流体被提升到导管 3 的水平向外展开的顶部，直到流体以圆形瀑布的形式溢出。

In order to prevent the wetting of the bearings of shaft 5, the central hub 2 of receptacle 1 is made to project above conduit 3. The latter is funnel shaped for reasons of economy, and also for the purpose

of reducing the speed and securing a smooth and even overflow. As the lift is inconsiderable, little power is needed to keep in motion a great volume of water and the impression produced on the observer is very striking. With the view of still further economizing energy, the bottom of receptacle 1 may be shaped as indicated by the dotted lines 12, in Fig. 2 so as to increase the velocity at the intake of the propeller.

为了防止轴 5 的轴承变湿, 容器 1 的中心轮毂 2 突出到导管 3 的上方。出于经济的原因, 以及为了降低速度和确保一个平滑的均匀的溢流, 后者是漏斗形的。由于升力很小, 所以只需要很少的动力就能使大量的水维持运动, 这给观察者留下了非常深刻的印象。为了进一步节约能量, 容器 1 的底部可以如图 2 中虚线 12 所示的形状, 以便增加螺旋桨入口处的速度。

To convey an idea of the results obtainable with a small apparatus, properly designed, it may be stated that by applying only $1/25$ of a horse-power to the shaft and assuming a lift of eighteen inches, more than one hundred gallons per minute may be propelled, the depth of the fluid passing over the flared top of conduit 3, one foot in diameter, being nearly one-half inch. As the circulation is extremely rapid the total quantity of liquid required is comparatively small. About one tenth of that delivered per minute will be, generally, sufficient. Such a cascade presents a singularly attractive appearance and this feature may be still further enhanced by artistic grouping of plants or other objects around it, in which case the whole contrivance may be hidden from view. Particularly beautiful displays, however, are obtainable by illumination which may be carried out in many ways. To heighten the effect, a colored, opalescent or phosphorescent fluid may be employed. Sterilizing, aromatic or radio-active liquids may also be used, when so desired. The usual fountains are objectionable in many places on account of the facility they afford for the breeding of insects. The apparatus described not only makes this impossible but is a very efficient trap. Unlike the old devices in which only a very small volume of water is set in motion, such a waterfall is highly effective in cooling the surrounding atmosphere. To still improve this action the free end 13 of the rotating shaft may be utilized to carry any kind of fan. The water may, of course, be artificially cooled.

为了传达使用适当设计的小型设备可获得的结果的想法, 可以说, 通过应用仅 $1/25$ 马力的轴, 并假设 18 英寸的升力, 每分钟可以推进超过 100 加仑, 流体的深度超过导管 3 的喇叭形顶部 (直径 1 英尺) 近 $1/2$ 英寸。由于循环极为迅速, 所需的液体总量相对较少。一般来说, 每分钟大约十分之一的流量就足够了。这种小瀑布呈现出非常吸引人的外观, 并且这种特征还可以通过对其周围的植物或其他物体进行艺术分组来进一步增强, 在这种情况下, 整个发明可以隐藏起来。然而, 特别漂亮的展现可以通过照明获得, 照明可以以多种方式进行。为了增强效果, 可以使用一种有色、乳白色或能发出磷光的流体。如果需要, 也可以使用消毒的、芳香的或放射性液体。普通的喷泉在许多地方是令人讨厌的, 因为它们容易滋生昆虫。所描述的设备不仅使这不可能, 而且是一个非常有效的陷阱。不像旧的设备, 其中只有非常少量的水用来运动, 这样的瀑布在冷却周围大气方面是非常有效的。为了进一步改善这种作用, 旋转轴的自由端 13 可以用来携带任何类型的风扇。当然, 水可以被人工冷却。

The device described may be modified in many ways and also considerably simplified. For example, the propeller may be fixed directly to the shaft of the motor and the latter supported conveniently from above when many of the parts illustrated in Fig. 1 and Fig. 2 may be dispensed with. In fact, receptacle 1 itself may be replaced by an independent tank or basin so that the entire apparatus will only consist of a funnel shaped conduit, motor and propeller as a unit. Such a construction is shown

in Fig. 3 and Fig. 4 in which 3 is a conical vessel provided with intake openings 4 and resting on a substantial base. A motor 14, carrying on a strong shaft 5 a propeller 9, is fixed to supports 15 which extend from the inner side of conduit 3 and may be integral with the same. Obviously, to insure perfect working the weight of the moving parts and axial reaction of the propeller should be taken up or balanced as by a thrust bearing 16, or other means.

所描述的设备可以以多种方式进行修改,并且也可以大大简化。例如,螺旋桨可以直接固定在发动机的轴上,当图 1 和图 2 所示的许多零件可以省去时,发动机的轴可以方便地从上面支撑。事实上,容器 1 本身可以由一个独立的箱体或盆代替,从而整个设备将仅包括作为一个单元的漏斗形导管、发动机和螺旋桨。这样的一个结构在图 3 和图 4 中展示,其中 3 是一个锥形容器,配有入口 4,并位于一个坚固的底座上。在一个坚固的轴 5 上的发动机 14 携带着螺旋桨 9,该发动机被固定到支撑件 15 上,支撑件 15 从导管 3 的内侧延伸,并且可以与导管 3 成为一体。显然,为了确保完美的工作,运动部件的重量和螺旋桨的轴向反作用力应该通过推力轴承 16 或其他装置来举起或平衡。

Apparatus of this description is especially intended for use in open basins or reservoirs in which it may be placed and put in action at short notice. When it is desired to produce large and permanent waterfalls the conduit 3 may be formed by masonry of appropriate architectural design.

这种描述的装置特别用于开放式的水池或水库,在那里它可以在短时间内被放置和投入使用。当希望产生大而持久的瀑布时,导管 3 可以由适当建筑设计的砖石构成。

The invention has an unlimited field of use in private dwellings, hotels, theaters, concert halls, hospitals, aquaria and, particularly, in squares, gardens and parks in which it may be carried out on a larger scale so as to afford a magnificent spectacle far more captivating and stimulating to the public than the insignificant displays now in use.

本发明在私人住宅、旅馆、剧院、音乐厅、医院、水族馆,特别是在广场、花园和公园中具有不受限制的使用领域,在这些地方,本发明可以大规模地实施,从而能够提供要比现在使用的微不足道的展示更加吸引和更能刺激公众的壮观景象。

I am well aware that artificial water falls have heretofore been exhibited and that fountains in which the same water is circulated are old and well known. But in all such cases independent pumps of small volumetric capacity were used to raise the water to an appreciable height which involved the expenditure of considerable energy, while the spectacle offered to the eye was uninteresting. In no instance, to my knowledge, has a great mass of fluid been propelled by the use of only such power as is required to lift it from its normal level through a relatively short space to that from which it overflows and descends as a cascade, nor have devices especially adapted for the purpose been employed.

我很清楚,人造瀑布迄今已被展出,在同样的水中循环着的喷泉是古老而众所周知的。但在所有这些情况下,小容量的独立泵被用来将水提高到一个可观的高度,这涉及相当大的能量的支出,而提供给眼睛的场面是无趣的。据我所知,在任何情况下,仅仅使用这种动力无法推动大量的流体,因为需要这种动力来将流体从其正常高度通过相对较短的空间提升到另一个高度,流体从该高度溢出并像瀑布一样下降,也没有采用特别适用于该目的的装置。

What I claim is:

我主张的是:

1. An artificial fountain consisting of an unobstructed conduit having an elevated overflow and adapted to be set in a body of water, and a propelling device for maintaining a rapid circulation of the water through the conduit.

1、一种人造喷泉，它由一个无阻碍的导管和一个推进装置组成，所述导管具有一个升高的溢流口，并适于安装在水体中，所述推进装置用于保持水在导管中快速循环。

2. An artificial fountain comprising in combination an unobstructed conduit having an elevated overflow and adapted to be set in a body of fluid, a propeller within the conduit for maintaining a rapid circulation of the fluid through the same, and a motor for driving the propeller.

2、一种人造喷泉，包括组合在一起的无阻碍的导管，该导管具有升高的溢流并适于设置在流体中，导管内的螺旋桨用于维持流体通过导管的快速循环，以及用于驱动螺旋桨的发动机。

3. The artificial fountain herein described, comprising in combination a receptacle, a central hollow conduit with an elevated overflow placed herein, a propeller within the conduit, and a motor for driving the propeller, so as to maintain a rapid circulation of fluid through the conduit.

3、本文所述的人造喷泉，包括组合在一起的一个容器；自身中设有溢流装置的中央中空导管；导管内的一个螺旋桨；以及用于驱动螺旋桨的发动机，从而保持流体通过导管的快速循环。

4. The artificial fountain herein described, comprising in combination, a receptacle, a conduit with elevated overflow set therein, a central hub extending up through the conduit, a rotary shaft extending therethrough, and a propeller carried by the shaft for maintaining a rapid circulation of fluid through the conduit.

4、这里描述的人造喷泉，包括组合在一起的一个容器；自身中设有溢流装置的中央中空导管；向上延伸穿过导管的中心轮毂；延伸穿过该轮毂的旋转轴；以及由轴携带的用于维持流体穿过导管快速循环的螺旋桨。

5. An artificial fountain comprising in combination with an unobstructed passage from the normal to the elevated fluid levels, of a propeller for maintaining a rapid circulation of the fluid through such passage and producing thereby a cascade with the expenditure of little energy.

5、一种人造喷泉，包括组合在一起的从正常液面到升高液面的无障碍通道；用于保持流体通过该通道的快速循环的螺旋桨，从而以很少的能量消耗产生瀑布。

6. An artificial fountain comprising a funnel shaped conduit adapted to be set in a body of fluid, and having openings near the lower end, and a propeller supported within the conduit and adapted when in operation to maintain a rapid circulation of water through the same.

6、一种人造喷泉，包括适于设置在流体中的漏斗形导管，该导管在下端附近具有开口，以及被支撑在导管内的螺旋桨，该螺旋桨适于在操作时维持水通过导管的快速循环。

In testimony whereof I affix my signature in the presence of two subscribing witnesses.

我在两名见证人在场的情况下签名特此为证。

NIKOLA TESLA.

尼古拉·特斯拉

Witnesses:

M. LAWSON DYAR,

WM. BOHLEBER.

见证人:

M.劳森·迪叶、WM.博勒伯。

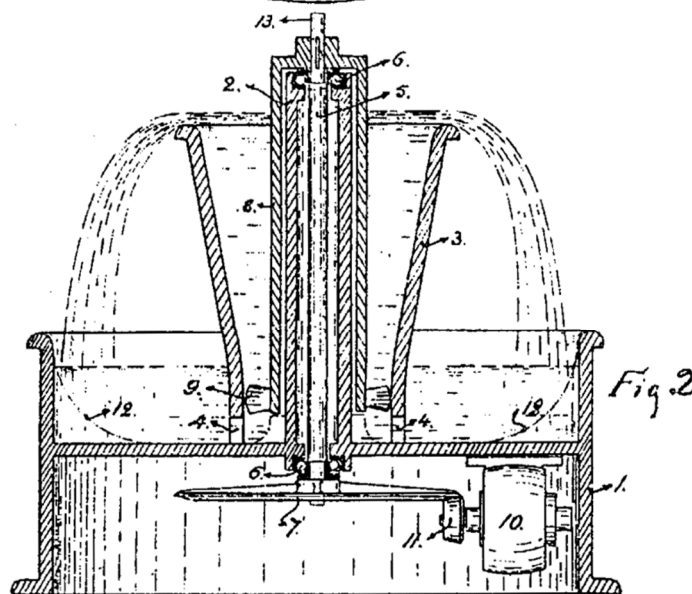
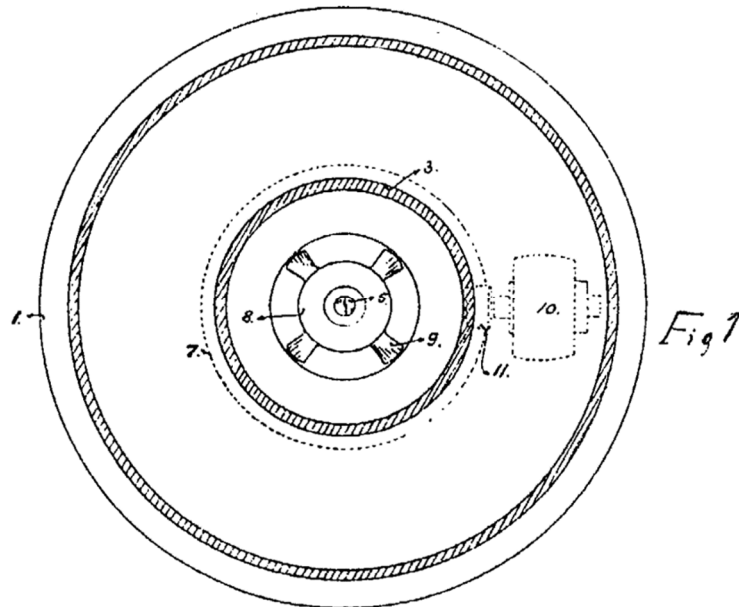
N. TESLA.
FOUNTAIN.

APPLICATION FILED OCT. 29, 1913.

1,113,716.

Patented Oct. 13, 1914.

2 SHEETS-SHEET 1.



WITNESSES:

H. H. Tectow.
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ATTORNEYS

N. TESLA.

FOUNTAIN.

APPLICATION FILED OCT. 28, 1913.

1,113,716.

Patented Oct. 13, 1914.

2 SHEETS—SHEET 2.

Fig. 3.

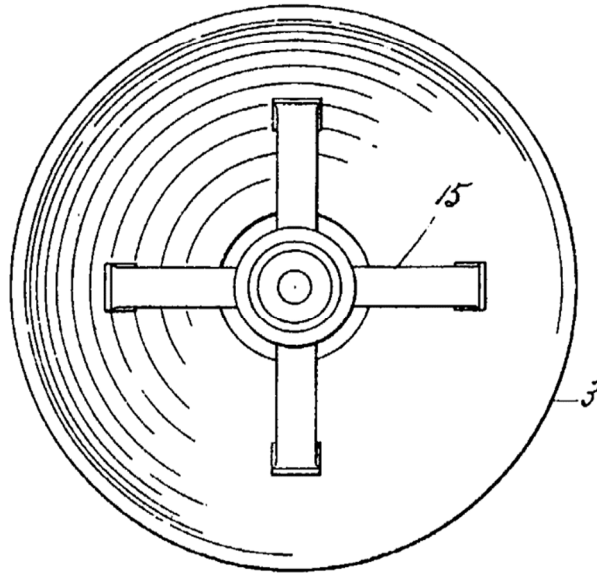
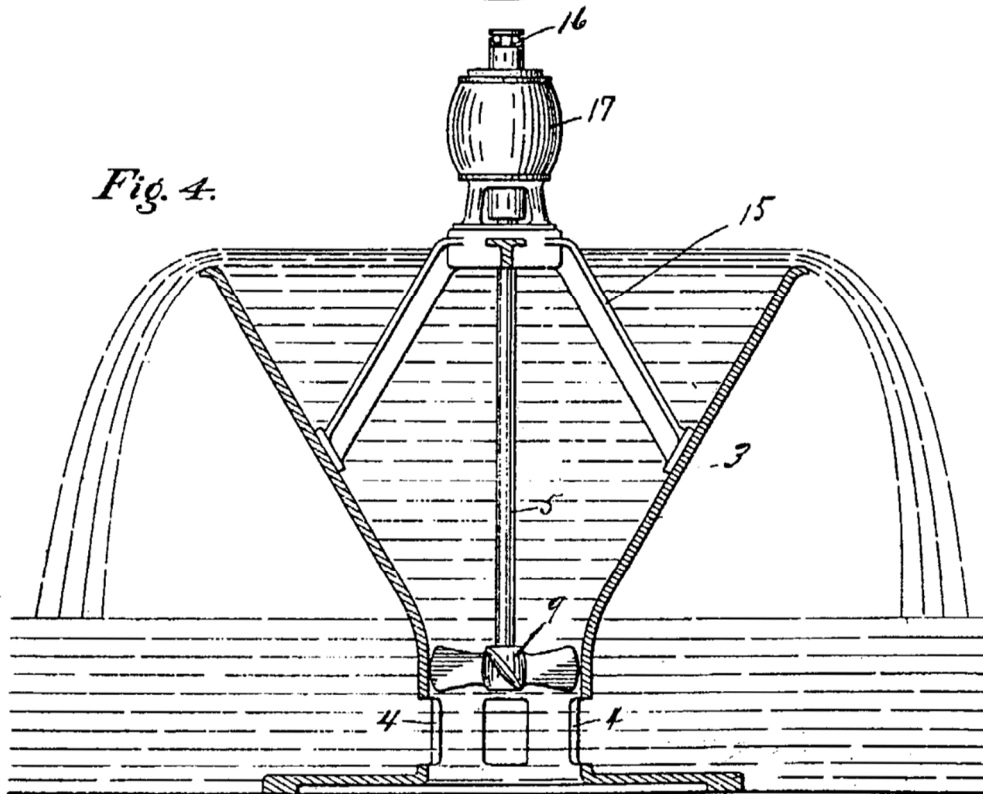


Fig. 4.



WITNESSES:

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ATTORNEYS

SPEED-INDICATOR.

速度计

NIKOLA TESLA, OF NEW YORK, N. Y., ASSIGNOR TO WALTHAM WATCH COMPANY,
OF WALTHAM, MASSACHUSETTS, A CORPORATION OF MASSACHUSETTS.

纽约州纽约市的尼古拉·特斯拉，将专利权转让给马萨诸塞州沃尔瑟姆市的
沃尔瑟姆钟表公司，它是马萨诸塞州的一家公司。

1,209,359. Specification of Letters Patent. Patented Dec. 19, 1916.

Application filed May 29, 1914. Serial No. 841,726.

专利证书说明书第 1,209,359 号。在 1916 年 12 月 19 日被授予专利。

申请于 1914 年 5 月 29 日。序列号为 841,726。

To all whom it may concern:

致所有相关人士：

Be it known that I, NIKOLA TESLA, a citizen of the United States, residing at New York, in the county and State of New York, have invented certain new and useful Improvements in Speed-Indicators, of which the following is a full, clear, and exact description.

众所周知，我、尼古拉·特斯拉、一位美国公民，居住在纽约州纽约郡纽约市，在速度计方面已经发明了某些新的和有用的改进，以下是该发明一个完整的、清晰的和准确的描述。

In the provision of speed indicators, that give direct readings of rate of motion,—for example shaft speeds in terms of revolutions per minute or vehicle speeds in miles per hour—it is obviously important that the instrument be simple, inexpensive and durable, and that its indications be correct throughout a wide range of speed. Likewise it is very desirable that its operation shall be subject to little or no appreciable deviation from accuracy under normal or expected extraneous changes, such as those of atmospheric density, temperature, or magnetic influence, in order that the structure may be free from any complications incident to the employment of specific means compensating for such varying conditions.

在提供可直接读取运动速率的速度指示器时——例如以每分钟转数为单位的轴速度或以每小时英里数为单位的车辆速度——显然重要的是该仪器简单、便宜和耐用，并且它的指示在很宽的速度范围内都是正确的。同样，非常希望它的操作在正常或预期的外界变化下，例如大气密度、温度或磁场影响下，其精度很少或没有明显的偏差，以便该结构可以避免由于采用补偿这种变化条件的特定装置而引起的任何复杂情况。

My present invention supplies a speed measuring appliance amply satisfying commercial demands as above stated, in a structure wherein the adhesion and viscosity of a gaseous medium, preferably air, is utilized for torque-transmission between the driving and driven members.

本发明提供了一种充分满足上述商业需求的速度测量装置，其结构是利用气体介质（最好是空气）的黏滞性和黏附性在驱动部件和从动部件之间传递扭矩。

More particularly, my invention provides a rotatable primary and a mechanically resistant or biased pivoted secondary element, cooperating through an intervening fluid medium to produce, inherently, without the use of compensating instrumentalities, angular displacements of the secondary element in linear proportion to the rate of rotation of the primary, so that the reading scale may be uniformly graduated. This latter advantage is secured through the application of novel principles, discovered by me, which will be presently elucidated.

更具体地说，我的发明提供了一种可旋转的初级组件和一种机械阻力组件或偏转枢转的次级组件，它们通过介于它们之间的流体介质来协作，在不使用补偿装置的情况下，固有地产生次级组件的角位移，该角位移与初级组件的旋转速度成线性比例，使得读数范围可以均匀地刻度。后一个优点是通过我发现的新颖原理的应用而获得的，下面将对其进行阐述。

In investigating the effects of fluids in motion upon rotative systems I have observed that under certain conditions to be hereafter defined, the drag or turning effort exerted by the fluid is exactly proportionate to its velocity relative to the system. This I have found to be true of gaseous and liquid media, with the distinction however, that the limits within which the law holds good are narrower for the latter, especially so when the specific gravity or the viscosity of the liquid is great.

在研究运动中的流体对旋转系统的影响时，我观察到，在下文定义的某些条件下，流体施加的拖动力或转向力与流体相对于系统的速度严格地成正比。我发现气态介质和液态介质都是如此，然而不同的是，对于后者，该定律适用的范围更窄，尤其是当液体的比重很大或黏度很大时。

Having determined the conditions under which the law of proportionality of torque to speed (rather than to the square of the speed or to some higher exponential function of the same) holds good, I have applied my discoveries in the production of new devices—essentially indicators of speed but having wider fields of use—which are, in many aspects, superior to other forms of speedometers.

确定了扭矩与速度（而不是速度的平方或更高的指数函数）的比例定律适用的条件后，我将我的发现应用到了新设备的生产中——本质上是速度指示器，但具有更广泛的应用领域——在许多方面优于其他形式的速度计。

Specifically I have devised rate-of-motion indicators which comprise driving and driven members with confronting, closely-adjacent, noncontacting, smooth, annular surfaces of large area, coacting in the transmission of torque through the viscosity and adhesion of interposed thin films of air,—mechanical structures offering numerous constructive and operative advantages. Furthermore, by properly designing and coordinating the essential elements of such instruments I have secured substantial linear proportionality between the deflections of the indicating or secondary element and the rate of rotation of the driving or primary member.

具体来说，我已经设计了运动速率指示器，其包括驱动件和从动件，这些部件具有大面积的面对面的、紧密相邻的、非接触的、光滑的环形表面，这些表面通过介于其间的空气薄层的

黏滯性和黏附性,在扭矩传递中共同协作,这种机械结构提供了许多结构上和操作上的优势。此外,通过适当地设计和协调此类仪器的基本组件,我已经确保了指示组件或次级组件的偏转和驱动组件或初级组件的旋转速率之间的基本线性比例。

The conditions more or less indispensable for this most perfect embodiment of my invention—that is to say, embodiment in a speed indicator approximating rigorous linear proportionality of deflection to speed—are:

对于我发明的这个最完美的实施例来说,也就是说,在速度指示器中的对于速度近似严格的线性偏转的体现,这种体现的或多或少必不可少的条件是——

1.The arrangement should be such that the exchange of fluid acting on the system is effectively prevented or minimized. If new fluid were permitted to pass freely between the elements there would be, as in a pump, with the rise and fall of velocity, corresponding changes of quantity and the torque would not vary directly as the speed, but as an exponential function of the same. Broadly speaking, such provision as is commonly made in hydraulic brakes for free circulation of fluid with respect to the rotative system, with the attendant acceleration and retardation of the flow, will generally produce a torque varying as the square of the speed, subject however, in practice, to influences which may cause it to change according to still higher powers. For this reason confinement of the fluid intervening between the primary and secondary elements of the system so that such active torque transmitting medium may remain resident, and not be constantly renewed, is vital to complete attainment of the desired linear proportionality.

1、这种布置应该使得作用在系统上的流体交换被有效地阻止或最小化。如果允许新流体在组件之间自由流动,就会像在泵中一样,随着速度的上升和下降,量和扭矩的相应变化不会直接随速度而变化,而是随速度的指数函数而变化。概括地说,这种设置通常用于液压制动器,以使流体相对于旋转系统自由循环,伴随着流动的加速和减速,通常会产生一个随着速度的平方而变化的扭矩,然而,在实践中,会受制于依据更高功率而导致扭矩发生改变的影响因素。由于这个原因,被限制在系统的初级组件和次级组件之间的流体,使得这种传递介质的有效扭矩可以保持驻留,而不是不断更新,这对于完全实现预期的线性比例是至关重要的。

2. The spaces or channels enclosing the active medium should be as narrow as practicable, although within limits this is relative, the range of effective separation increasing with the diameter of the juxtaposed rotative surfaces. My observations have established that when the spacing is so wide as to accommodate local spiral circulation in the resident fluid between the confronting areas, marked departures from rigorous proportionality of torque to speed occur. Therefore in small instruments with primary members of but few inches diameter, it is desirable that the channels should be as narrow as is mechanically feasible with due regard to the importance of maintaining the noncontacting relation of the rotative parts.

2、包围活性介质的空间或通道应该尽可能地窄,尽管在一定限度内这是相对的,有效分离的范围随着并列旋转表面的直径而增加。我的观察已经证实,当间距宽到足以容纳面对面区域之间的驻留流体中的局部螺旋循环时,会发生扭矩与速度的严格比例的显著偏离。因此,在初级部件的直径只有几英寸的小型器械中,考虑到维持旋转部件的非接触关系的重要性,

通道应在机械上尽可能的窄。

3. The velocity of the fluid relative to the system should be as small as the circumstances of the case will permit. When a gas such as air is the active medium, it may be 100 feet per second or even more, but with liquids speeds of that order cannot be used without detriment.

3、流体相对于系统的速度应在情况允许的情况下尽可能小。当气体如空气是活性介质时，它可能是每秒 100 英尺甚至更高，但对于液体来说，这种速度不会毫无损害的情况下使用。

4. The bodies exposed to the action of the fluid should be symmetrically shaped and with smooth surfaces, devoid of corners or projections which give rise to destructive eddies that are particularly hurtful.

4、暴露在流体作用下的物体应该是对称的形状，并且具有光滑的表面，没有能引起特别有害的破坏性涡流的转角或突起。

5. The system should be so shaped and disposed that no part of the moving fluid except that contained in the spaces or channels can effect materially the torque. If this rule is not observed the accuracy of the instrument may be impaired to an appreciable degree, for even though torque transmission between the confronting surfaces is proportional, there may yet be a component of the rotary effort (through the fluid coacting with the external surfaces) proportional to an exponential function of the speed. Hence it is desirable that by a closely investing casing, or other means, the torque-transmitting effect of fluid outside of the channels between the rotative parts be minimized.

5、该系统的形状和布置应确保除了被包含在间隔中或通道中的流体，运动流体的其他任何部分都不会对扭矩产生实质性影响。如果不遵守这一规则，仪器的准确性可能会受到相当大的影响，因为即使面对面表面之间的扭矩传递是成比例的，也可能存在与速度的指数函数成比例的旋转力分量（通过与外表面协作的流体）。因此，希望通过紧密包围的外壳或其他方式，使旋转部件之间的通道外部的流体的扭矩传递效应最小化。

6. In general the flow of the medium should be calm and entirely free from all turbulent action. As soon as there is a break of continuity the law above stated is violated and the indications of the device cease to be rigorously precise. These requirements can be readily fulfilled and the above discoveries applied to a great many valuable uses, as for indicating the speed of rotation or translation, respectively, of a shaft, or a vehicle, such as an automobile, locomotive, boat or aerial vessel; for determining the velocity of a fluid in motion; for measuring the quantity of flow in steam, air, gas, water or oil supply; for ascertaining the frequency of mechanical and electrical impulses or oscillations; for determining physical constants; and for numerous other purposes of scientific and practical importance.

6、一般来说，介质的流动应该是平静的，完全不受任何湍流的影响。一旦连续性中断，就违反了上述定律，装置的指示就不再严格。这些要求可以容易地满足，并且上述发现适用于许多有价值的用途，例如分别用于指示轴或交通工具的旋转速度或平移速度，所述交通工具例如汽车、机车、船只或航空器；用于确定运动中流体的速度；用于测量蒸汽、空气、气体、水或油的供应流量；用于确定机械和电脉冲或电振荡的频率；用于确定物理常数；以及许多其他具有科学和实际重要性的目的。

The nature and object of the invention will be clearly understood from the succeeding description with reference to the accompanying drawings in which:

参考附图，从随后的描述中将清楚地理解本发明的性质和目的，其中：

Figure 1 represents a vertical cross section of a speed indicator or hand tachometer embodying the above principles; Fig. 2 is a horizontal view of the instrument disclosing part of the scale, and Figs. 3 and 4 are diagrammatic illustrations showing modified constructions of the main parts in a similar device.

图 1 表示体现上述原理的速度指示器或手动转速表的垂直截面图；图 2 是展示了部分刻度尺的仪器的水平视图，图 3 和图 4 是展示类似装置中的初级部件的改进结构的示意图。

Referring to Fig. 1, 1 is a pulley-shaped metal disk from three to four inches in diameter constituting the freely-rotatable primary element. It is fastened to a driveshaft 2 which is turned to fit a hole in the central hub 3 of the casting 4. A ball bearing 5 set in a recess of the former, serves to take up the thrust against the shoulder 6 of the shaft and insures free running of the same. In close proximity to the disk 1 is the thin shell 7 in the form of a cup, this being the secondary element of the system. It is made of stiff and light material, as hard aluminum, and is fixed to a spindle 8, supported in nearly frictionless bearings or pivots 9 and 10. As before remarked the spacing between the two elements, (1 and 7), should best be as small as manufacturing conditions may make feasible. By way of example, a separation,—in an instrument of the diameter suggested,—of say .015" to .025" will be found effective for working purposes and also within a reasonable range of inexpensive mechanical attainment. Still smaller spacing is, however, theoretically desirable. One of the bearings aforesaid is screwed into the end of the shaft 2 and the other into a plug 11 in a slotted tubular extension 12 of a casting 13. The running bearing in the shaft, though not of perceptible influence on the indications, may be replaced by a stationary support behind and close to shell 7, as at 8. A torsional spring 14 is provided, for biasing the pivoted element 7, having its ends held in collars 15 and 16, which can be clamped, as by the set screws shown, the one to the spindle 8 and the other to the plug 11. The bearings 9 and 10 are capable of longitudinal adjustment and can be locked in any position by check nuts 17, and 18, but this refinement is generally unnecessary. The castings 4 and 13, in the construction specifically shown, when screwed together form a casing that closely invests the rotative system. This casing forms one available means for preventing communication of torque from the primary element 1 to the secondary member 7 through the medium contacting with the external surfaces of both, to any extent sufficient for materially modifying the torque due to the films between the elements, but other means to this end may be substituted. The chamber enclosed within the casting should be airtight for highest accuracy in order that the density of the contained medium may remain constant, although in the vast majority of cases where air is used as the active agent, the slight effects of ordinary changes of temperature and density of the external atmosphere can be ignored, as they are in a measure neutralized by the concomitant variations in the resilience of the torsional spring and as they do not seriously affect the proportionality of deflections observed. However, when great precision is essential, a seal 19 of suitable packing, paste or amalgam may be employed. Obviously the working parts may be contained in a separate, perfectly tight reservoir filled with fluid of any desired character, the rotating member or disk 1 being driven by a magnet outside. This expedient has been adopted in numerous instances and is quite familiar. The casting 4 has a window or opening 20, closed by a piece of transparent substance, such as celluloid, for enabling the readings to be made on the scale which is engraved upon or glued to the rim of the

indication-controlling element or shell 7. The shaft 2 is armed with a steel or rubber tip 21, and a handle 22 of fiber or other material is fastened to the central hub of casting 13, completing the hand tachometer.

参考图 1, 1 是直径为 3-4 英寸的滑轮状金属盘, 构成可自由旋转的初级组件。它被紧固到一个驱动轴 2 上, 驱动轴 2 被转动以贴合铸件 4 的中心轮毂 3 中的孔。设置在轮毂 3 的凹槽中的滚珠轴承 5 用于承受轴肩 6 上的推力, 并确保轴肩 6 的自由运转。靠近圆盘 1 的是杯形的薄壳 7, 这是系统的次级组件。它由硬而轻的材料制成, 如硬铝, 并被固定到心轴 8 上, 心轴 8 被支撑在几乎无摩擦的轴承或枢轴 9 和 10 上。如前所述, 两个组件 (1 和 7) 之间的间距最好在制造条件可行的情况下尽可能小。举例来说, 在建议直径的仪器中, 0.015 英寸至 0.025 英寸的间距对于工作目的是有效的, 并且在合理的廉价机械范围内也是有效的。然而, 理论上更小的间距是理想的。前述轴承中的一个被拧入轴 2 的端部, 另一个被拧入在铸件 13 的开槽管状延伸部 12 中的塞子 11。轴中的运转轴承虽然对指示没有明显的影响, 但可以由壳体 7 后面的和靠近壳体 7 的一个静态支撑代替, 如在 8 处的支撑。用于偏离枢转组件 7 的扭转弹簧 14 的端部被夹在套环 15 和 16 中, 套环 15 和 16 可以被夹紧, 如通过所示的定位螺钉, 一个被夹紧到轴 8, 另一个夹紧到插头 11。轴承 9 和 10 能够纵向调节, 并且可以通过防松螺母 17 和 18 锁定在任何位置, 但是这种改进通常是不必要的。在具体展示的结构中, 铸件 4 和 13 在被拧在一起时形成紧密包围旋转系统的外壳。该外壳形成了一种可用的工具, 用于防止扭矩通过与初级组件 1 和次级组件 7 的外表面接触的介质从初级组件 1 传递到次级组件 7, 由于组件之间的薄层, 该传递达到足以显著改变扭矩的任何程度, 但是为此目的可以用其它装置代替。被密封在铸件内的腔室应该是气密的, 以达到最高的准确度, 以便所包含的介质的密度保持恒定, 尽管在绝大多数情况下, 空气被用作活性剂, 外部大气的温度和密度的普通变化的轻微影响可以忽略不计, 因为它们在一定程度上被扭簧的弹性的伴随变化所抵消, 并且因为它们不会严重影响所观察到的偏转的比例关系。然而, 当高精度是必不可少时, 可以使用适合的填料、糊状物或汞合金的密封件 19。显然, 工作部件可以被包含在独立的、完全密封的容器中, 该容器填充有任何期望特性的流体, 旋转部件或圆盘 1 由外部的磁体驱动。这种权宜之计已被采用在许多情况下, 是非常熟悉的。铸件 4 具有由一块透明物质 (如赛璐珞) 封闭的窗口或开口 20, 用于能够在刻度尺上进行读数, 刻度尺被刻在或粘在指示控制组件或外壳 7 的边缘上。轴 2 装备有钢质或橡胶的尖端 21, 纤维或其他材料制成的一个手柄 22 被紧固到铸件 13 的中心轮毂上, 从而完成了手持转速表。

Fig. 2 in which like numbers designate corresponding parts is self-explanatory.

图 2 中相同的数字表示相应的部分, 这是不言而喻的。

Attention may be called to the pointed index 23 placed in the opening 20 and marking, when the instrument is not in use, zero on the scale. The latter can be readily put in proper position by turning the collar 16 to the desired angle.

可以注意放置在开口 20 和正在标记的尖头指示器 23, 当仪器不使用时, 该指示器在刻度上标记零。通过将轴环 16 转动到所需的角, 可以容易地将刻度放置在适当的位置。

As described the device is adapted for use in the manner of an ordinary hand tachometer. In taking the revolutions of a shaft, the tip 21 is placed firmly into the central cavity of the former, as usual, with the result of entraining the disk 1 and bringing it to full speed by friction. The active medium, preferably air, in the narrow channels between the rotating and pivoted members, by virtue of its adhesion and

viscosity, is set in circular motion by the primary element, and, giving up the momentum imparted to it on the light secondary shell 7, causes the latter to turn until the torque exerted is balanced by the retractile force of spring 14. Care should be taken to employ a spring the resistance of which increases linearly with displacement, so that the deflections are exactly proportionate to the torsional effect, as otherwise the indications will not be true to scale, even though the instrument be perfect in other respects. In order that the torque should vary rigorously as the speed, the fluid particles in the minute channels between the rotating and pivoted members should move in circles and not in spirals, as necessarily would be the case in a device in which pumping action could take place, and either by making both the primary and secondary elements effectively-imperforate to prevent central admission of air, or otherwise so constructed and conditioned that air may not freely pass from center to periphery between the elements of the moving system unchanging residence of a definite body of the active medium within the system is insured. Where pumping action,—that is to say, acceleration or retardation of fluid movement other than circularly with the primary element,—takes place the deflections increase more rapidly than the speed. It follows that centrifugal force, which is the essential active principle in pumping, must be negligible to avoid compression of the air at the periphery which might result in a sensibly increased torque. To appreciate this, it should be borne in mind that the resistance of a circular strip of the active area would, under such conditions, be proportionate to the fourth power of the diameter so that a slight compression and attendant increase of density of the medium in the peripheral portion would cause a noticeable departure from rigorous proportionality. Experience has demonstrated that when the space is very narrow, as is indispensable for the fullest attainment of the desired proportionality, the centrifugal effect of the active fluid, be it gaseous or liquid, is so small as to be unobservable. The inference is that the actions in the narrow space between the rotative members are capillary or molecular and wholly different in principle from those taking place in a pumping device in which the fluid masses are alternately retarded and accelerated. The scale, which, as will be apparent from the preceding, is uniform in an instrument best embodying my invention, may be so graduated that each degree corresponds to a certain number of revolutions per unit of time, and for convenience, (in shaft-speed indicators as herein shown), the constant is made a round number, as 100. The establishment of this relation through the adjustment of the torsional spring is facilitated by varying the distance between the parts 1 and 7, thus modifying the torque and consequently the deflection, (the torque varying inversely as the distance) while always keeping within the range throughout which linear proportionality is attainable. In calibrating it is necessary to make but one observation comparative with some positive standard and to plot the balance of the scale accordingly. The conditions above set forth being realized, the reading will be accurately proportionate to the speed and the constant will be correct through the whole range contemplated in the design. Therein lies a very important advantage bearing on manufacture and introduction of devices of this character over those now in use which are based on an empirical scale, tedious to prepare, and unreliable. When desired, the instrument may be rendered dead beat through magnetic or mechanical damping, but by making the torque very great, and the inertia of the secondary element very small, such objectionable complication may be avoided. With a given separation the turning effort is proportionate to the product of the velocity of rotation, the density of the fluid and the aggregate area of the active surfaces, hence by increasing either of these factors the torsion can be augmented at will. It obviously follows that the pull exerted on a circular disk will be as the third power of the diameter and one way of attaining the object is to use a large plate. Other and better ways are illustrated in Figs. 3 and 4 in which the rotating and pivoted elements are composed of interleaved disks or cylinders. The first arrangement permits an indefinite increase of the torque, the second commends itself through the facility of adjustment of the force by varying the active area.

如上所述，该装置适于以普通手持转速计的方式使用。在进行轴的旋转时，尖端 21 通常被牢固地放置在轴的中心空腔中，结果是带动圆盘 1 并通过摩擦使其达到全速。在旋转部件和枢转部件之间的狭窄通道中的活性介质，最好选择为空气，由于其黏滞性和黏附性，空气被初级组件设置成圆周运动，并且，放弃被施加在轻质次级壳体 7 上空气的动量，导致壳体转动，直到施加的扭矩被弹簧 14 的可缩回力所平衡。应注意使用一个弹簧，其阻力随位移线性增加，这样偏转就与扭转效应成正比，否则，即使仪器在其他方面是完美的，指示对于刻度也不会是真实的。为了使扭矩随着速度严格变化，在旋转部件和枢转部件之间的微小通道中的流体粒子应该以圆周运动，而不是以螺旋运动，这在泵送动作可能发生的装置中是必须的，或者通过使初级组件和次级组件都有效地无孔隙以防止空气进入中心，或者以其它方式构造和调节，使得空气不能在运动系统的组件之间从中心自由地传递到外周，确保了活性介质的明确主体在系统内的未变化的驻留。在泵送作用发生的地方，也就是说，在流体运动加速或减速，而不是利用初级组件产生循环的地方，偏转的增加比速度的增加快得多。由此可见，离心力是泵送的基本有效原理，必须变得微不足道，以避免外周空气的压缩，这种空气的压缩可能导致一个明显增加的扭矩。为了理解这一点，应该记住，在这种情况下，有效区域的圆形带的阻力将与直径的四次方成正比，使得轻微的压缩和随之而来的外周部分中介质密度的增加将导致明显偏离严格的成比例关系。经验表明，当空间非常狭窄时（这对于最大程度地达到所需的比例关系是不可或缺的），活性流体（无论是气体还是液体）的离心效应非常小，以至于无法观察到。推论是，在旋转部件之间的狭窄空间中的作用是毛细管作用或分子作用，并且在原理上完全不同于在泵送装置中发生的作用，在泵送装置中，流体物质被交替地减速和加速。从前面可以明显看出，刻度在最好地体现我发明的仪器中是均匀一致的，可以这样分度，使得每一度对应于每单位时间的一定转数，并且为了方便起见（在这里所示的轴速指示器中），该常数是一个整数，如 100。通过改变部件 1 和 7 之间的间距，有助于通过调节扭转弹簧来建立这种关系，从而改变扭矩并和由此造成的偏转，（扭矩与距离成反比地变化），同时总是保持在可获得线性比例的范围内。在校准时，只需将一个观察结果与某个正面标准进行比较，并相应地绘制刻度的平衡。实现上述条件后，读数将精确地与速度成正比，并且常数将在设计中预期的整个范围内都是可预期的。与目前使用的那些基于经验刻度、准备繁琐且不可靠的装置相比，这种装置的制造和引入具有一个非常重要的优势。当需要时，可以通过磁性阻尼或机械阻尼使仪器停止摆动，但是通过使扭矩非常大，并且使次级组件的惯性非常小，可以避免这种令人讨厌的复杂情况。对于一个给定的间距，旋转力与旋转速度、流体密度和有效表面的总面积的三者乘积成正比，因此通过增加这些因素中的任何一个，可以随意增大扭矩。显然，施加在圆盘上的拉力将是直径的三次方，达到这个目的的一种方法是使用一个大的板。图 3 和图 4 展示了其他更好的方式，其中旋转组件和枢转组件由交错的圆盘或圆柱体组成。第一种布置允许扭矩的无限增加，第二种布置值得推荐的地方是通过改变有效面积来调节力的便利性。

For many reasons it is decidedly advantageous to employ air as the agent in an instrument intended for popular purposes, especially those involving rough use and inexpert handling, since thereby the cost of manufacture may be kept low, the need for en sealing minimized and susceptibility of the parts to easy disassembling and replacement attained.

由于许多原因，在用于大众目的的仪器中使用空气作为媒介是绝对有利的，特别是那些涉及粗暴使用和不熟练操作的仪器，因为由此可以保持低的制造成本，最小化密封的需要，并且部件易于拆卸和更换。

It is, therefore, desirable that the annular confronting surface of the elements,—whether of disk or

cylindrical form,—be sufficiently extensive for securing ample torque to make the instrument approximately dead beat and to minimize the percentage of error due to mechanical imperfections.

因此，理想的是，组件（无论组件是圆盘形还是圆柱形）的环形面对面表面要足够大，以保证足够的扭矩，来使得仪器近似无差拍，并使由于机械缺陷引起的误差百分比最小。

The foregoing description contains, I believe, all the information necessary for enabling an expert to carry my invention into successful practice. When using the indicator in the manner of an ordinary vehicle speedometer, as in an automobile, the shaft 2 is rigidly or flexibly geared to the driving axle or other suitable part and readings are made in miles per hour, as is customary. As will be apparent many other valuable uses may be served, since the primary element may be connected in suitable electrical or mechanical manner with any rotating part, the speed of which may be translated through a linearly proportionate constant into the desired terms of time and quantity, and the reading scale may be calibrated in such terms. It will also be evident that by accurate workmanship, following the teachings of my invention, instruments at once simple, rugged, and scientifically accurate may be constructed for a very wide range of uses in either huge or tiny sizes; and, since the commercial requirements of accuracy in many fields gives a reasonable range of permissive error, manufacturing considerations may lend to deviations from strict observance of some of the conditions that I have indicated as best attaining a rigorous proportionality of reading. The provision of simple mechanical elements, cooperating primarily only through the viscosity and adhesiveness of the air films intervening therebetween and substantially free from need for en sealing and from error caused by changes of extraneous conditions, especially temperature, affords striking commercial advantages unattainable in any form of speedometer of which I am aware. Therefore while I have described in detail for the purpose of full disclosure a specific and highly advantageous embodiment of my invention, it will be understood that wide variations in the mechanical development thereof may be made without departure from its spirit within the scope of the appended claims.

我相信，前面的描述包含了使一名专家能够成功实施我的发明所必需的所有信息。当以普通车辆速度计的方式使用指示器时，如在汽车中，轴 2 刚性地或柔性地与驱动轴或其它合适的部件啮合，并且读数以英里/小时为单位，这是惯例。显而易见的是，由于初级组件可以以合适的电气方式或机械方式与任何旋转部件连接，其速度可以通过线性比例常数转换成所需的时间项和数量项，并且读数刻度可以以这种方式校准，因此可以提供许多其他有价值的用途。同样显而易见的是，通过精确的工艺，遵循我的发明的教导，简单、坚固和科学上精确的仪器可以被制造成适用于非常广泛的用途，无论是巨大的还是微小的尺寸；此外，由于许多领域的商业精度要求给出了合理的容许误差范围，制造考虑因素可能会导致偏离严格遵守某些条件，我已经指出这些条件是获得读数的严格比例关系的最佳方式。提供简单的机械组件，初级仅通过介于这些组件之间的空气薄层的黏滞性和黏附性来协作，并且基本上不需要密封，也不存在由外界条件，尤其是温度的变化引起的误差，这提供了我所知道的任何形式的速度计都无法获得的显著的商业优势。因此，尽管为了全面公开的目的，我已经详细描述了我的发明的一个特定的且非常有优势的实施例，但是应该理解的是，在所附权利要求的范围内，在不脱离其精神的情况下，可以对其机械发展进行广泛的改变。

What I claim is:

我主张的是：

1. In combination, fixed supporting means, disconnected alined driving and driven shafts rotatably mounted in said supporting means, relatively thin spaced rigid pieces of material rigidly connected to and arranged coaxially about said driven shaft with broad surfaces opposite each other, and other relatively thin spaced rigid pieces of material rigidly connected to and arranged coaxially with the driving shaft, and being alternated with the first-mentioned pieces between them and having their broad surfaces adjacent to and spaced from the broad surfaces of said other pieces, said pieces all arranged in air, through which torque is frictionally transmitted from the second-mentioned pieces to those first-mentioned.

1、存在一个组合，它包括：被固定的支撑装置；可旋转地安装在所述支撑装置中的不连接的对齐的驱动轴和从动轴；被刚性连接到所述从动轴并围绕所述从动轴同轴布置的相对薄的被间隔的刚性材料片；以及被刚性地连接到驱动轴并与驱动轴同轴布置的其它的相对薄的被间隔刚性材料片；并且使它们的宽表面与所述其它材料片的宽表面相邻并间隔开，所述材料片全部布置在空气中，扭矩通过空气从第二次提到的材料片摩擦地传递到首先提到的材料片上。

2. In combination, in a speedometer, disconnected alined driving and driven shafts, a fixed support, said shafts being mounted in said support, a coiled spring having one end secured to said fixed support and the other end secured to said driven shaft, relatively thin spaced rigid pieces of material rigidly connected to and arranged coaxially about said driven shaft with their broad surfaces opposite each other, other relatively thin spaced rigid pieces of material rigidly connected to and arranged coaxially with the driving shaft, and being alternated between said first-mentioned pieces and spaced therefrom, and an air body filling the spaces between said pieces and constituting the torque-transmitting friction medium therebetween.

2、在一个速度计中存在一个组合中，它包括：不连接的对齐的驱动轴和从动轴；一个固定支架，所述轴安装在所述支架中；一端固定到所述固定支架而另一端固定到所述从动轴的螺旋弹簧；被刚性连接到所述从动轴并围绕所述从动轴同轴布置的相对薄的被间隔开的刚性材料片，它们的宽表面彼此面对面；其它相对薄的被间隔开的刚性材料片被刚性地连接到驱动轴并与驱动轴同轴布置，并且在所述的首先提到的材料片之间交替并与其间隔开；以及填充所述材料片之间的空间的空气体，并构成材料片之间的扭矩传递摩擦介质。

3. In combination, in a speedometer, disconnected alined driving and driven shafts, a frame having bearings for said shafts, a coiled spring whose inner end is secured to said driven shaft and having its outer end secured to said frame, spaced rigid pieces of material rigidly connected to and arranged about said driven shaft, and other spaced rigid pieces of material rigidly connected to and arranged about said driving shaft, the former pieces being alternated between the latter pieces in spaced relation with their broad surfaces in close juxtaposition, and with the interspaces between said spaced pieces forming a convoluted air-containing channel therebetween open to the surrounding air.

3、在一个速度计中存在一个组合中，它包括：不连接的对齐的驱动轴和从动轴；具有用于所述轴的轴承的一个框架；其内端固定到所述从动轴并且其外端固定到所述框架的螺旋弹簧；被刚性连接到所述从动轴并且围绕所述从动轴布置的被间隔开的刚性材料片；以及被刚性连接到所述驱动轴并且围绕所述驱动轴布置的其它被间隔开的刚性材料片；前者部件在后者部件之间以被隔开的关系交替，它们的宽表面紧密并排，并且所述的被隔开的部件之间的

空隙在它们之间形成了向周围空气开放的回旋式的容纳了空气的通道。

4. In combination, disconnected aligned driving and driven shafts, a fixed support, bearings therefor in said support, a coiled spring having one end secured to the driven shaft and its other end secured to said fixed support, a cup-shaped body secured to one end of said driving shaft coaxially, spaced rigid relatively thin plates secured to said body in parallel relation to each other, another cup-shaped body secured coaxially to said driven shaft and enclosing said plates at their outer edges in spaced relation thereto, other spaced rigid relatively thin plates secured to the second-mentioned body and extending between the first-mentioned plates in spaced relation thereto, and an air body filling the spaces between said pieces frictionally to transmit torque from the driving structure to the driven structure.

4、存在一个组合，它包括：不连接的对齐的驱动轴和从动轴；一个固定支架；在所述支架中的轴承；一端固定到从动轴而另一端固定到所述固定支架的螺旋弹簧；同轴固定到所述驱动轴一端的杯形主体；以彼此平行的关系被固定到所述主体的被间隔开的刚性的相对较薄的板；另一个杯形主体同轴地被固定到所述从动轴上，并在所述板的外边缘以与其间隔开的关系包围所述板；其它被间隔开的刚性的相对较薄的板固定到第二次提到的杯形主体上，并以与第一次提到板间隔开的关系在这些板之间延伸；还有摩擦地填充所述部件之间的空间的空气主体，以将扭矩从驱动部件传递到从动部件。

5. The combination with means for support and driving and driven shafts rotatably supported thereby, of means to transmit torque from the driving shaft to the driven shaft comprising opposed material-pieces respectively connected with the driving shaft and the driven shaft and arranged to present toward each other relatively-extensive, non-contacting, closely-adjacent surfaces, and a gaseous medium in which said pieces work, said gaseous medium serving frictionally to connect the said opposed material-pieces for transmission of torque from the driving shaft to the driven shaft.

5、存在一个组合，它包括：用于支撑的工具和由此支撑的可旋转的驱动轴和从动轴；以及将扭矩从驱动轴传递到从动轴的工具。后者包括分别与驱动轴和从动轴连接的面对面的材料片，该材料片设置成具有彼此相对延伸的、非接触的、紧密相邻的表面；以及在所述材料片之间中工作的气体介质，所述气体介质用于摩擦地连接所述面对面的材料片，以便将扭矩从驱动轴传递到从动轴。

6. In combination, driving and driven elements suitably supported and having confronted annuli always presenting to each other relatively-extensive, non-contacting, closely-adjacent surfaces, said surfaces disposed in a gaseous friction medium, whereby the driving member, by its rotation, induces rotary motion of the driven member through the drag of the gaseous medium intervening between said annuli.

6、存在一个组合，它包括：被适当支撑并具有面对面环面的驱动组件和从动组件；该环面总是面向彼此呈现相对大范围的、非接触的、紧密相邻的表面；所述表面被设置在气体摩擦介质中，借此驱动部件利用自身旋转，通过介于所述环面之间的气体介质的拖动来引起从动部件的旋转运动。

7. In combination, driving and driven elements having in opposed, closely adjacent, non-contacting relation, relatively extensive friction surfaces, and an interposed gaseous body, through which the driving member frictionally drags the driven element.

7、存在一个组合，它包括：具有面对面的、紧密相邻的、非接触关系的、相对大的摩擦表面的驱动组件和从动组件；以及介于这些组件间的气态主体，驱动部件通过该气态主体摩擦地拖动从动组件。

8. In a speedometer, the combination with supporting means, separately-rotatable driving and driven shafts mounted therein, biasing means for the driven shaft, and means to indicate rotary displacement of the biased shaft in terms of speed, of pieces rotatively carried by said respective shafts, having relatively-extensive, non-contacting, closely-adjacent surfaces arranged to confront each other, and a gaseous medium intervening between said confronting surfaces to coact therewith frictionally to transmit torque from the driving shaft to the biased driven shaft.

8、在一个计速器中，存在一个组合，它包括：支撑工具；安装在其中的可独立旋转的驱动轴和从动轴；用于从动轴的偏转装置；以及根据速度指示被偏转轴的旋转位移的工具；所述被偏转轴由所述相应的轴可旋转地携带，具有相对大范围的、非接触的、紧密相邻的彼此面对的表面；以及介于所述面对面的表面之间的气态介质，以与其摩擦地共同协作，从而将扭矩从驱动轴传递到被偏转的从动轴。

9. In a speedometer, the combination of a primary element rotatable at varying speeds, having a plurality of spaced annuli, a biased secondary element, arranged for separate rotary movement and adapted and arranged to indicate speed variations by the extent of its displacement, said secondary element having a plurality of spaced, thin, light annuli, the annuli of said two elements interleaved in non-contacting, closely-adjacent relation always to present toward each other extensive friction surfaces, and an air body, through the films of which, intervening between said annuli, rotation of the primary element may induce speed-indicating displacement of the secondary element.

9、在一个计速器中，存在一个组合，它包括：具有多个被间隔的环形的可变速旋转的初级组件；一个被偏转的次级组件，所述次级组件被设置用于单独的旋转运动，并适于通过其位移的程度来指示速度变化；所述次级组件具有多个被间隔的、薄的、轻质的环，所述两个组件的环以非接触、紧密相邻的关系交错，总是呈现朝向彼此的大范围摩擦表面；还有空气主体，通过空气主体的薄膜，初级组件的旋转可以引起次级组件的速度指示位移，所述薄膜介于所述环之间。

10. A speedometer wherein a primary, variable-speed element, and a biased, speed-indication-controlling secondary element, that are suitably supported for separate movement, have opposed extensive friction surfaces in non-contacting juxtaposition for frictional communication of power from the primary element to the secondary element through a gaseous medium that intervenes between said friction surfaces.

10、一种速度计，其中的一个初级变速组件和一个被偏转的转速显示控制次级组件被适当地支撑用于独立运动，这两个组件具有非接触并排的面面对面的大范围摩擦表面，用于通过介于所述摩擦表面之间的气体介质将动力从初级组件摩擦传递到次级组件。

11. An air drag speedometer, wherein a primary, variable-speed element and a biased speed-indication-controlling secondary element, that are suitably mounted for separate rotary movement in an air-containing casing, have opposed, extensive friction-surfaces in non-contacting juxtaposition, for

frictional communication of torque from the primary element to the secondary element through the medium of the casing-contained air.

11、一种空气拖动速度计，其中的一个变速初级组件和一个被偏转的转速显示控制次级组件被适当地安装在一个容纳空气的壳体中，用于独立的旋转运动，它们具有非接触并排的面对面的、大范围的摩擦表面，用于扭矩通过外壳容纳的空气媒介实现从初级组件到次级组件的摩擦传递。

12. In a speedometer, the combination of an air containing casing, a primary element and a secondary element mounted in said casing for separate movement, said elements having extensive surfaces exposed toward each other in closely contiguous but non-contacting relation for frictional communication of power to one from the other through the intervening air, means resiliently to resist displacement of the secondary element, and means to indicate displacement of the secondary element in terms of speed.

12、在一种空气阻力速度计中，存在一个组合，它包括：容纳空气的一个壳体；安装在所述外壳中用于独立运动的一个初级组件和一个次级组件，所述组件具有紧密邻接但非接触的朝向彼此暴露的大面积表面，该表面用于通过中间空气将动力从一个摩擦组件传递到另一个组件；阻碍次级组件位移的弹性工具；以及根据速度指示次级组件位移的工具。

13. In combination, in a speedometer, disconnected shafts respectively carrying driving and driven elements that have annuli affording continuous extensive friction surfaces in always confronting non-contacting closely-spaced relation, the driven element being light and biased by a light spring, for ready response to torque transmitted frictionally by air, and the air film-spaces between the elements constituting an open tortuous channel; and an air containing casing enclosing the driving and driven elements, its contained air body forming the sole effective means of torque transmission between the elements.

13、在一个速度计中存在一个组合，它包括：不连接的不同轴，分别承载驱动组件和从动组件，这两个组件具有能提供连续的大面积摩擦表面的环，这些摩擦表面总是面对面非接触的紧密间隔关系，从动组件是轻质的，并且由轻质弹簧偏转，用于对由空气摩擦传递的扭矩做出迅速响应，并且组件之间的空气薄层空间构成开放的弯曲通道，以及包围驱动组件和从动组件的容纳空气的壳体，其容纳的空气体形成组件之间扭矩传递的唯一有效手段。

14. In a speedometer, the combination of rotatable driving and driven elements having in opposed, closely-adjacent non-contacting relation, relatively extensive friction surfaces, means to bias the driven element, means to indicate rotary displacement of said driven element in terms of speed, a casing enclosing said elements and containing air, said contained air body extending in films between the friction surfaces, and forming the sole effective means of torque transmission between the driving and driven elements.

14、在一个速度计中存在一个组合，它包括：可旋转的驱动组件和从动组件，它们具有面对面且紧密相邻的非接触关系；相对大的摩擦表面；偏转从动组件的工具；根据速度指示所述从动组件的旋转位移的工具；封闭所述组件并容纳空气的外壳，所述被包含的空气主体在摩擦表面之间以薄层形式延伸，并形成在驱动组件和从动组件之间传递扭矩的唯一有效工具。

15. In combination, driving and driven elements having in opposed non-contacting relation relatively extensive friction surfaces so closely adjacent that through an interposed gaseous body the driving member frictionally drags the driven member with a torque linearly proportionate to the speed of the former.

15、存在一个组合，它包括：驱动组件和从动组件具有面对面的非接触关系的相对大的摩擦表面，这些摩擦表面如此紧密地相邻，以至于驱动组件可以通过介于摩擦表面之间的气体与前者们的速度成线性比例的扭矩摩擦地拖动从动组件。

16. A rate indicator wherein a freely-rotatable primary and a biased, indication-controlling secondary member, suitably supported for separate movement, have opposed, non-contacting surfaces in such close proximity that through an intervening viscous fluid medium torque is transmitted to the secondary member in linear proportion to the speed of the primary.

16、一种速度指示器，其中的可自由旋转的初级部件和被偏转的指示控制次级部件，被适当地支撑用于独立的运动，这些部件具有面对面的、非接触的表面，这些表面如此靠近，使得通过介于这些表面之间的黏性流体介质，扭矩以与初级部件的速度成线性比例的关系被传递到次级部件。

17. A rate indicator wherein a freely rotatable primary and a biased, indication-controlling secondary element, suitably supported for separate movement are operatively linked through an intervening viscous and adhesive air body, said elements having opposed, extensive non-contacting surfaces so closely adjacent that the torque transmitted to the secondary element through said air body is substantially in linear proportion to the speed of the primary element.

17、一种速度指示器，其中可自由旋转的初级组件和被偏转的指示控制次级组件通过介于它们之间的具有黏滞性和黏附性的空气主体可操作地连接起来，所述组件具有面对面的、大范围的非接触表面，它们如此紧密地相邻，使得通过所述空气主体传递到次级部件的扭矩基本上与初级部件的速度成线性比例。

18. In a speed indicator the combination of two rotatively movable driving and driven members having opposed non-contacting extensive surfaces confining between them a practically constant body of torque-transmitting fluid medium, said surfaces being so closely proximate that the torque transmitted from the driving to the driven member is substantially proportional to the rate of rotation of the former.

18、在一种速度指示器中，存在一个组合，它包括：两个可旋转运动的驱动部件和从动部件，它们具有面对面的非接触的大面积表面，在它们之间限定了一个实际上恒定的传递扭矩的流体介质体，所述表面非常接近，使得从驱动部件传递到从动部件的扭矩基本上与前者们的转速成正比。

19. A speed indicator comprising, in combination, a rotatable body, a second angularly movable body, means to resist displacement of the latter proportionately to the torque applied thereto, and a fluid medium interposed between them, said bodies having opposed annular surfaces in such close proximity that pumping of the medium therebetween is prevented and the deflections of the second body are made proportionate to the speed of the other.

19、一种速度指示器，它包括组合在一起的一个可旋转主体；一个次级角位移主体；阻碍次级角位移主体以与施加到其上的扭矩成比例地进行位移的工具；以及介于它们之间的流体介质，所述主体具有面对面的环形表面，这些表面非常接近，从而防止了它们之间介质的泵送，并且次级主体的偏转与另一个主体的速度成正比。

20. A speed indicator, comprising, in combination, a rotatable, variable speed primary element, and a light, pivoted, torsionally-resisted, indication-controlling secondary element, suitably mounted for separate movement and operatively linked with the former through an interposed gaseous medium, said elements having opposed, annular, non-contacting surfaces so extensive and closely proximate that the whirling medium exerts a strong and steady turning effort upon the secondary element, substantially in linear proportion to the speed of the primary.

20、一种速度指示器，包括由一个可旋转的、可变速的初级组件和一个轻质的、被枢转的、抗扭转的、指示控制的次级组件所形成的组合，该次级组件被适当地安装成可独立运动，并通过介入的气体介质与初级组件可操作地连接，所述组件具有面对面的、环形的、非接触的表面，这些表面如此充分地、紧密地靠近，使得旋转介质在次级组件上施加一个强而稳定的旋转力，该旋转力基本上与初级组件的速度成线性比例。

21. The combination, in a rate indicator, of a freely rotatable primary and a torsionally-resisted indication controlling secondary member mounted for separate movement, with their opposed non-contacting symmetrical surfaces confining therebetween a resident fluid body and arranged in such close proximity that the fluid, entrained in circles by the rotating primary exerts a torque on the secondary member in substantially linear proportion to the speed of the former.

21、在一种速度指示器中，一个可自由旋转的初级部件和一个以扭转的方式被阻碍的可控制指示的次级部件的组合，这些部件被安装成可独立运动，它们的面对面的非接触对称表面在它们之间限制了一个驻留的流体，并且它们布置得如此接近，使得由转动的初级部件带动成圆周运动的流体在次级部件上施加一个与初级部件的速度基本上成线性比例的扭矩。

22. In combination, in a speed-indicator, a rotatable primary element, a biased secondary element, a fluid body between and around them, said elements having opposed non-contacting extensive surfaces in such close proximity that the resident fluid body therebetween transmits torque to the secondary in substantially linear proportion to the speed of the primary element, and means for minimizing the rotary effort transmitted through the fluid around the elements.

22、存在一个组合，它包括：一个可旋转的初级组件；一个被偏转的次级组件；位于它们之间和它们周围的流体，所述组件具有面对面的非接触的大面积表面，这些表面非常接近，使得它们之间的驻留流体以与初级组件的速度基本成线性比例的方式将扭矩传递到次级组件，以及用于最小化由组件周围的流体传递的旋转力的工具。

23. A rate indicator comprising a structure confining a substantially unchanging body of fluid and including an extensive annular surface of a freely rotatable member, arranged to impart circular motion to the fluid, and a confronting annular surface of an indication-controlling angularly-displaceable member, arranged to take up momentum of the fluid, said surfaces being so closely proximate that the torque transmitted through the fluid is proportional to the speed of the rotatable member.

23、一种速度指示器，包括一个用来限制基本上不变的流体的结构；以及一个自由旋转部件的大范围的环形表面，这些表面被布置用于使流体进行圆周运动；还有一个控制指示的角度可移动部件的环形表面，被布置用于吸收流体的动量，上述表面如此接近，使得通过流体传递的扭矩与旋转部件的速度成比例。

24. A speed indicator comprising two elements mounted for separate movement in a fluid medium, one of the elements being freely rotatable at varying speeds, and the other pivoted and biased against angular displacement, said elements having opposed non-contacting extensive symmetrical surfaces in such close proximity that torque is transmitted through the intervening fluid body in substantially linear proportion to the speed of the primary element, and a member surrounding said elements and minimizing the flow of the fluid along the exterior surfaces of said secondary element.

24、一种速度指示器，包括两个安装成在流体介质中用于独立运动的组件，其中一个组件可在不同的速度下自由旋转，另一个组件被枢转并被偏转以抵抗角位移，所述组件具有面对面的非接触的大范围对称表面，这些表面非常接近，使得扭矩以与初级组件的速度基本上成线性比例的方式通过介于中间的流体传递；以及围绕所述组件并使沿着所述次级组件的外表面的流体的流动最小化的部件。

25. In a device of the character described, the combination of a rotatable primary element, a spring-biased secondary element, a casing surrounding the same and a fluid body filling the casing, said elements having opposed non-contacting annular surfaces in such close proximity that the rotary effort exerted through the fluid body on the secondary element is proportionate to the speed of the primary element, some parts of said casing being so closely proximate to said elements as to minimize torque-transmitting flow of the fluid along the exterior surfaces of the secondary element.

25、在所述特征的一个装置中，存在一个组合，包括：一个可旋转的初级组件；一个弹簧偏转的次级组件；围绕该次级组件的外壳和填充该外壳的流体，所述组件具有面对面的非接触环形表面，这些表面如此靠近，使得通过流体施加在次级组件上的旋转力与初级组件的速度成正比，所述外壳的一些部分如此靠近所述组件，以至于能最小化沿着次级组件的外表面的流体的传递扭矩的流动。

26. An air drag speedometer wherein a rotatable primary variable-speed element and a biased pivoted secondary element, mounted for separate movement in an air-containing casing, have opposed extensive smooth annular surfaces in such close juxtaposition that torque is transmitted through the air intervening between said surfaces in substantially linear proportion to the speed of the rotatable primary element.

26、一种空气拖动速度计，其中一个可旋转的初级变速组件和一个偏转枢转的次级组件被安装成能在一个容纳空气的壳体中独立运动，它们具有面对面的大面积的光滑环形表面，这些表面如此紧密地并置，使得扭矩可以通过介于所述表面之间的空气传递，与可旋转的初级组件的速度基本上成线性比例。

27. A speed indicator comprising a closed fluid-filled casing, primary and secondary elements mounted therein, the one for rotation and the other for torsionally resisted angular displacement, said elements having opposed non-contacting extensive annular surfaces forming therebetween a smooth intervening

channel wherein confined fluid may move in circles under the influence of the primary member, and between them and the interior surfaces of the casing surrounding channels wherein fluid contiguous to the secondary element may receive circular movement from the primary element, said surfaces being so closely proximate that torque transmission through the fluid is linearly proportionate to the speed of the primary element.

27、一种速度指示器，包括一个封闭的充有流体的壳体；安装在壳体中的初级组件和次级组件，一个用于旋转，另一个用于扭转地抵抗角位移，所述组件具有面对面的非接触延伸的环形表面，在它们之间形成一个平滑的中间通道，其中受限制的流体可以在初级组件的影响下在通道中做圆周运动，并且在初级组件和围绕通道的壳体的内表面之间，邻近次级组件的流体可以从初级组件接收圆周运动，所述表面非常接近，使得通过流体传递的扭矩与初级组件的速度成线性比例。

28. The combination, in a speed indicator, of a closed casing, a fluid body and two rotatively-movable members therein, means for rotating one of the members, means for resisting displacement of the other, and means controlled by the last named member for reading its displacement in terms of speed, said two members having opposed, non-contacting imperforate annular surfaces in such close proximity as to confine therebetween a film of fluid through which torque is transmitted to the resistant member in linear proportionality to the speed of the rotatable member.

28、在一个速度指示器中，存在一个组合，它包括：一个封闭的壳体；一个流体主体和在流体中两个可旋转运动的构件；用于旋转其中一个构件的工具；用于阻止另一个构件位移的工具；以及由最后提到的构件控制的用于根据速度读取其位移的工具，所述两个构件具有面对面的、非接触的无孔环形表面，这两个表面非常接近，从而在它们之间限制了一层流体薄层，扭矩通过该流体薄层与可旋转构件的速度成线性比例地传递到阻止构件。

29. The combination with a closed fluid containing casing, of a plurality of symmetrical bodies with smooth surfaces rotatably mounted therein, means for torsionally restraining some of said bodies, and means for rotating the others, said bodies being placed with their surfaces in such close proximity to each other and to the walls of the casing that the rotating bodies will cause an even and undisturbed circular motion of the fluid and transmit torque to the torsionally restrained bodies in proportion to the speed of the others.

29、存在一个组合，它包括：容纳流体的一个壳体；多个具有光滑表面并且被安装成可旋转的在壳体中的对称主体；用于扭转约束所述主体的工具；以及用于旋转其它主体的工具；所述主体被放置成它们的表面彼此非常接近并且非常接近壳体的内壁，使得旋转主体将引起流体的均匀且不受干扰的圆周运动，并且与其它主体的速度成正比地将扭矩传递到扭转约束主体上。

30. In a speed measuring instrument, the combination of driving and driven members having in opposed closely adjacent non-contacting relation relatively extensive smooth friction surfaces, and an interposed gaseous body through which the driving member frictionally drags the driven member.

30、在一种速度测量仪器中，存在一个组合，它包括：具有面对面的紧密相邻的非接触关系的相对大范围的平滑摩擦表面的驱动部件和从动部件；以及一种介于其间的气体主体，驱动

部件通过该气体主体摩擦地拖动从动部件。

31. A tachometer comprising, in combination, a rotatably mounted shaft, a smooth annular body fixed thereto, a similar pivoted body, a torsion spring for the latter, indicating means movable with said pivoted body, and an air-containing casing, said bodies having their annular surfaces in such close, non-contacting proximity that the intervening air transmits torque to the pivoted body in substantially linear proportion to the speed of the rotatable body.

31、一种转速计，其组合包括：一个可旋转安装的轴；一个被固定到该轴上的光滑环形体；一个类似的枢转主体；用于该枢转主体的一个扭簧；可与所述枢转主体一起移动的指示工具；以及包含空气的壳体，所述主体的环形表面如此紧密、非接触地接近，使得介于之间的空气将扭矩传递到枢转主体，该扭矩与可旋转主体的速度基本成线性比例。

32. A tachometer comprising, in combination, a rotatably mounted shaft, a primary element carried thereby, a pivoted secondary element, a torsion spring therefore permitting its angular displacement substantially in proportion to the torque, indicating means operated by the pivoted element and graduated with substantial uniformity, and a fluid-containing casing closely investing part of said rotative system, the opposed surfaces of the elements being so closely proximate to each other and to part of the casing that the fluid-transmitted torque causing deflections of the pivoted body is substantially proportionate to the speed of the primary element.

32、一种转速表，其组合包括：一个可旋转安装的轴；由该轴承载的初级组件；一个枢转的次级组件；因此允许其角位移基本上与扭矩成比例的一个扭簧；由枢转组件操作且刻度基本上均匀的指示工具；以及紧密包围所述旋转系统的一部分的容纳流体的壳体；组件的面对面表面彼此紧密靠近并紧密靠近壳体的一部分，使得导致枢转主体偏转的流体所传递的扭矩基本上与初级组件的速度成正比。

In testimony whereof I affix my signature in the presence of two subscribing witnesses.

我在两名见证人在场的情况下签名特此为证。

NIKOLA TESLA.
尼古拉·特斯拉

Witnesses:

M. LAWSON DYAR,
THOMAS J. BYRNE.

见证人:

M.劳森·迪叶、托马斯·J·伯恩。

N. TESLA.
SPEED INDICATOR.
APPLICATION FILED MAY 29, 1914.

1,209,359.

Patented Dec. 19, 1916.

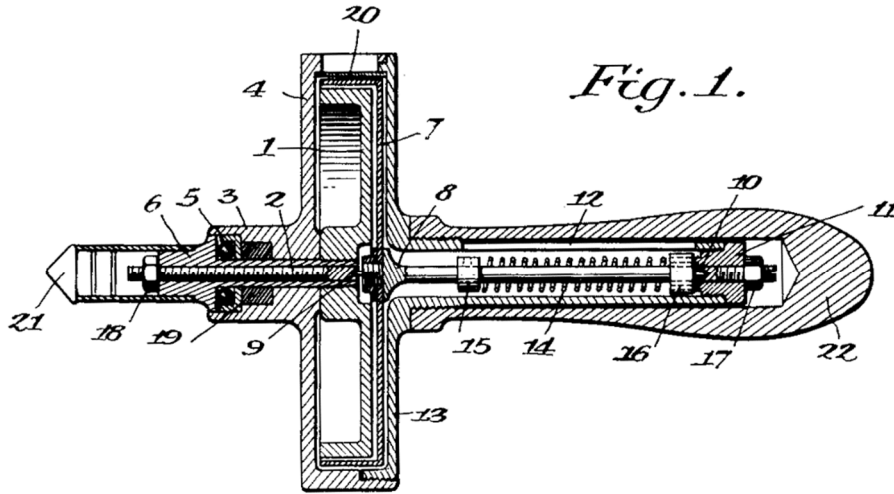


Fig. 1.

Fig. 3.

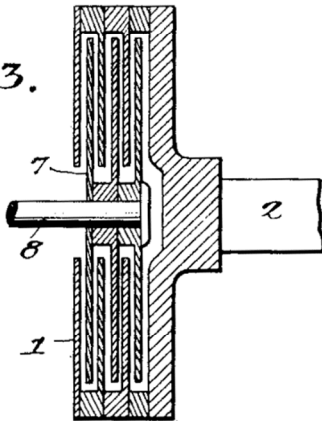
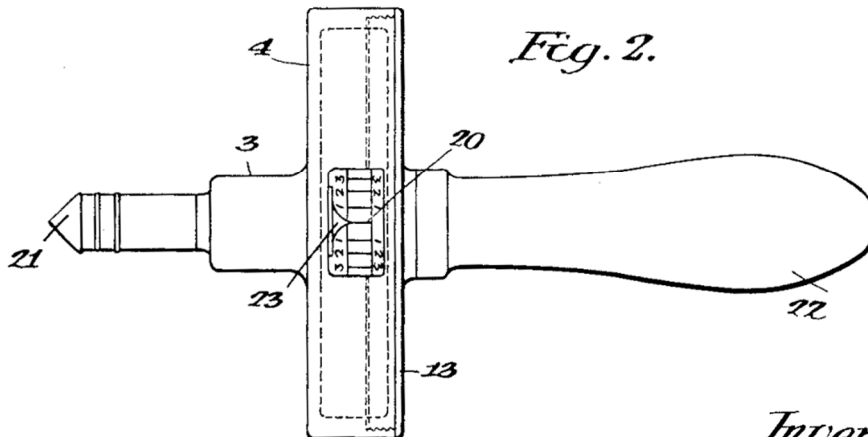


Fig. 4.

Fig. 2.



Inventor:
Nikola Tesla
Gorie Rainesway,
attorney

SPEED-INDICATOR.

速度指示器

NIKOLA TESLA, OF NEW YORK, N. Y., ASSIGNOR TO WALTHAM WATCH COMPANY,
OF WALTHAM, MASSACHUSETTS, A CORPORATION OF MASSACHUSETTS.

纽约州纽约市的尼古拉·特斯拉，将专利权转让给马萨诸塞州沃尔瑟姆市的
沃尔瑟姆钟表公司，它是马萨诸塞州的一家公司。

1,274,816. Specification of Letters Patent. Patented Aug. 6, 1918.

Application filed December 18, 1916. Serial No. 137,691.

专利证书说明书第 1,274,816 号。在 1918 年 8 月 6 日被授予专利。

申请于 1916 年 12 月 18 日。序列号为 137,691。

To all whom it may concern:

致所有相关人士：

Be it known that I, NIKOLA TESLA, a citizen of the United States, residing at New York, in the county and State of New York, have invented certain new and useful Improvements in Speed-Indicators, of which the following is a full, clear, and exact description.

众所周知，我、尼古拉·特斯拉，一位美国公民，居住在纽约州纽约郡纽约市，在速度指示器方面已经发明了某些新的和有用的改进，以下是该发明一个完整的、清晰的和准确的描述。

Among the desiderata of speedometer construction are these: that the torque exerted upon the secondary, or indication-giving, element shall be linearly proportional to the speed of the primary member rather than to the square of the speed (as instanced in centrifugal speedometers); that the torsional effect at low speeds shall be strong and steady so that particular delicacy of construction may not be necessary and that minute causes of theoretical errors (such as bearing-friction, spring-inequalities and the like) may be negligible in effect; that the torque may be substantially unaffected by changes of extraneous conditions, as of temperature, atmospheric density and magnetic influence; that the instrument be inherently dead-beat and relatively insensible to mechanical vibration; and that ruggedness, simplicity and economy, for attendant durability, manufacturing facility and low cost, be attained. My present speedometer realizes these advantages and provides, also, an appliance that is suitable for great, as well as very small, velocities, exact in its readings, uniformly graduated as to scale, and unaffected by changes of temperature or pressure within as well as without.

速度表结构的要求包括：施加在次级组件或指示组件上的扭矩应与初级组件的速度成线性比例，而不是与速度的平方成线性比例（例如在离心式速度表中）；在低速时的扭转效应应强而稳定，因此不需要特别精细的结构，微小的理论误差原因（如轴承摩擦、弹簧不平衡等）在效果上可以忽略不计；扭矩基本上不受外界条件变化的影响，如温度、大气密度和磁场影响；仪器本身是无差拍的，并且对机械振动相对不敏感；并且获得了坚固性、简单性和经济

性，以及随之而来的耐用性、制造的便利性和低成本。我目前的速度计实现了这些优点，并提供了一种大小速度都适用的装置，其读数准确、刻度分度均匀、不受内外温度或压力变化的影响。

In my Patent No. 1,209,359, dated December 19, 1916, I have described a new type of speed measuring instrument wherein the adhesion and viscosity of a gaseous medium, preferably air, is utilized for torque-transmission from a primary driving to a secondary pivoted and torsionally restrained member under conditions such that the rotary effort exerted upon the latter is linearly proportional to the rate of rotation of the former. The principles of that invention find place in my present construction. Such "air-drag" speedometers have been found capable of meeting satisfactorily the commercial requirements for both large and small instruments respectively adapted to measure relatively high and low speeds, but nevertheless it is true that although such instruments, when built for high-speed indication, may be of sturdy construction, they must, when designed for low-speed measurement, be built with great precision and delicacy. This because the inertia of the secondary element must be kept extremely small for desirable promptness of response to very slow starting speeds and consequent feebleness of the turning effort. In some instances, therefore, it is highly desirable to employ a transmitting medium giving a much greater torque than air with concomitant extension of the low-range of accurate speed reading, quickness of response, practicable decrease of size of parts and lessening of sensitiveness to disturbances such as vibration of the instrument as a whole.

在我的 1916 年 12 月 19 日被授予的第 1,209,359 号专利中，我描述了一种新型的速度测量仪器，其中气体介质（最好为空气）的黏滞性和黏附性被用于从初级驱动部件到次级枢转和扭转受限部件的扭矩传递，其条件是施加在后者上的旋转力与前者的旋转速率成线性比例。那个发明的原理在我现在的构造中找到了位置。已经发现，这种“空气拖动”速度计能够令人满意地满足对分别适用于测量相对高速和相对低速的大型和小型仪器的商业要求，但是，尽管这种仪器在制造用于高速指示时确实如此，但在被设计用于低速测量时，它们必须被制造得非常精确和灵敏。这是因为次级组件的惯性必须保持得极小，以便对非常慢的起动速度和随之而来的微弱转向力做出理想的快速响应。因此，在某些情况下，非常希望采用一种传递介质，该介质给出比空气大得多的扭矩，同时伴随着精确速度读数的低速范围扩展、快速响应、部件尺寸的实际减小以及对干扰（例如仪器整体的振动）的敏感性的降低。

All of the stated objects I accomplish by employing as the torque-transmitting medium between the driving and driven elements a body of suitable liquid, (e.g., mercury) under conditions (as set forth in my prior application referred to) proper to secure linear proportionality of deflections, and, further, by making provision automatically to compensate for the changes in the viscosity of the liquid that accompany variations of temperature. The latter equipment is unnecessary in my air-drag speedometer, but mercury and other liquids of relatively great density that might be employed for my present purposes have not the quality of approximate self-compensation for temperature changes that inheres in air, owing to the fact that the viscosity of such a liquid decreases rapidly as its temperature rises, and so to a successful "mercury-drag" instrument temperature compensation is requisite.

我采用合适的液体（例如水银）作为驱动组件和从动组件之间的扭矩传递介质，并且进一步地，向伴随温度变化的液体黏度的变化自动提供补偿，通过以上方法我实现了所有所述的目的，所述合适的液体（例如水银）处于适当的条件下（如在我的先前申请中所提到的）以确保偏转的线性比例。所述补偿在我的空气拖动速度计中是不必要的，但水银和其他可以用于

我目前目的的密度相对较大的液体不具备对空气中固有的温度变化进行近似自我补偿的品质，因为事实上这种液体的黏性随着温度的升高而迅速下降，所以对于一个成功的“水银拖动”仪器的温度补偿是必要的。

The underlying ideas of this invention can be carried out in various ways and are capable of many valuable uses, but for purposes of disclosure, specific reference to a form of speed indicator designed for use on an automobile is adequate.

本发明的基本思想可以用各种方式实现，并且能够有许多有价值的用途，但是为了公开的目的，具体参考一种被设计用于汽车上的速度指示器就足够了。

As in the structure described in my stated prior application, I provide driving and driven members with confronting, closely-adjacent, non-contacting, smooth, annular friction surfaces, co-acting for transmission of torque through the viscosity and adhesion of interposed thin films of a suitable medium—in this case mercury—under conditions to prevent free exchange of fluid acting on the system, to prevent its local circulation and eddying, to maintain its flow calm and non-turbulent, and to secure as low velocity of the medium with respect to the system as the circumstances of the case may make desirable. These conditions all aid in the attainment of rigorous linear proportionality of deflection of the secondary to the speed of rotation of the primary element under given temperature conditions. Additionally, by suitable construction I make it possible to obtain a nearly perfect compensation for temperature changes so that the deflections may be rigorously proportionate to speed within limits of temperature variation wider than I believe likely to occur in the practical use of the instrument. I attain this compensatory result by providing thermo-responsive means to vary the effective area of the secondary element upon which the medium acts in approximately inverse proportion to temperature-effected changes of viscosity of the medium, and as a preferred specific means to this end, I dispose a body of the liquid beyond, but communicating with, the active portion of the liquid medium and of such quantity that, in effectively the same measure as viscosity and, consequently, the torque is diminished or increased with temperature changes, the active liquid-contacting area of the secondary member is enlarged or reduced owing to the expansion or contraction of the fluid.

如在我所陈述的先前申请中描述的结构中，我提供了具有面对面的、紧密相邻的、非接触的、光滑的、环形摩擦表面的驱动部件和从动部件，这些部件共同协作用于通过介入它们之间的适当介质（本例中是水银）的薄层来传递扭矩，在防止作用在系统上的流体的自由交换和防止流体的局部循环和涡流的条件下，保持流体平静地且无湍流地流动，并视情况而定，确保介质相对于系统的速度尽可能低。这些条件都有助于在给定的温度条件下，次级部件的偏转与初级部件的转速达到严格的线性比例。此外，通过合适的结构，我可以为温度的变化获得一个几乎完美的补偿，以便在比我相信仪器的实际使用中很可能发生的温度变化范围更宽的温度限度内，偏转可以严格地与速度成正比。我通过提供热响应型工具来改变次级组件的有效面积来获得这种补偿结果，介质作用在该次级组件上的有效面积与温度引起的介质黏附性的变化近似成反比，并且作为为此目的的一个首选特定工具，我在液体介质的活性部分之外布置这种液体主体，但是与液体介质的活性部分连通，并且使得对该液体主体的量的测量与黏度同样有效，因此，扭矩随着温度变化而减小或增大，由于流体的膨胀或收缩，次级部件的有效液体接触面积也在增大或减小。

In the drawing Figure 1 is a top view of a speedometer; Fig. 2 is a central vertical section therethrough;

Fig. 3 shows a spring adjusting arrangement; and Fig. 4 and Fig. 5 are diagrams explanatory of the compensating principle.

在附图中：图 1 是速度计的俯视图；图 2 是从中穿过的中央垂直截面图；图 3 展示了一个弹簧调节装置；图 4 和图 5 是补偿原理的示意图。

In Fig. 4 the primary or driving member is a cup 10 carried by a freely rotatable vertical shaft 11. Within it the cylinder-formed secondary member 12 is mounted on a spindle 13, journaled in jewels 14 and 15 of negligible friction, for pivotal displacement against the restraint of a spiral spring 16, connected at its ends respectively to fixed support 17 and spindle-collar 18, so that by pivotal displacement of the secondary cylinder against the resisting spring tension, the torsional effort exerted on the secondary member may be measured. The spring is such that its displacements are linearly proportionate to the force applied. The lower portion 19, of the cup-chamber is a reservoir filled with the liquid, 20, as mercury, and the liquid normally extends part way up the very narrow interspace 21 between the two elements to contact with less than the whole of their confronting friction surfaces. With mercury as the medium, in an instrument with a secondary cup of one inch diameter I find an interspace-width of 0.05 inch to be satisfactory.

在图 4 中，初级部件或驱动部件是由可自由旋转的垂直轴 11 承载的杯 10。在杯内部，圆筒形的次级部件 12 被安装在心轴 13 上，轴颈被安装在可以忽略摩擦的宝石 14 和 15 中，用于产生枢转位移，用于抵抗螺旋弹簧 16 的约束，螺旋弹簧 16 在自身端部分别连接到被固定的支撑件 17 和轴环 18，从而利用次级圆筒抵抗弹簧张力的枢转位移，可以测量施加在次级部件上的扭转力。弹簧的位移与施加的力成线性比例。杯室的下部分 19 是一个充满液体 20（如水银）的容器，液体通常向上延伸到两个组件之间的非常狭窄的间隙 21 的一部分，以接触少于它们面对面的整个摩擦表面。以水银为介质，在具有一个直径一英寸的次级杯的一个仪器中，我发现 0.05 英寸的间隙宽度是令人满意的。

It will now be seen that when shaft 11 is rotated the mercury in the cup is entrained and in turn produces a drag upon the pivoted member 12, the torsional effort being directly proportionate to the active area, viscosity of the fluid and the speed of rotation and, inversely, to the width of the interspace 21 or distance between the rotated and pivoted surfaces. If v be coefficient of viscosity, A the active area, s the speed and d the distance between the juxtaposed rotating and pivoted surfaces, all of the quantities being expressed in proper units, then the twisting force

$$F = \frac{vAs}{d} \text{ dynes.}$$

现在可以看出，当轴 11 被转动时，杯中的水银被带走，并进而在枢转部件 12 上产生拖拽，扭转力直接与有效面积、流体黏附性和旋转速度成正比，与间隙 21 的宽度或旋转表面和枢转表面之间的距离成反比。如果 v 是黏附性系数， A 是有效面积， s 是速度， d 是并排的旋转面和枢转面之间的距离，所有的量都用适当的单位表示，那么扭力

$$F = \frac{vAs}{d} \text{ 达因。}$$

When, through changes in the external conditions or work performed on the fluid, the temperature of the same is raised, two effects, separate and distinct, are produced. In the first place, the viscosity is diminished according to a certain law, reducing correspondingly the torque, on the other hand, the fluid expands thereby enlarging the areas of the active, or liquid-contracting, surfaces of the elements with an attendant increase of rotary effort. Obviously, then, if it is possible so to relate these actions that they mutually annul each other upon any change of temperature, a complete compensation may be obtained. This result, I have ascertained, can be almost perfectly realized with a liquid, as mercury, by properly proportioning the volume of the chamber-contained, or compensating, component 20c of the liquid and the component 20a of the liquid in the interspace 21. With a view to simplifying this explanation, be it supposed that the force F is wholly due to the liquid component 20a (the drag exerted on the bottom face of cylinder 12 being assumed to be negligible and the bearings to be frictionless). It will be evident that under these conditions the active area will increase as the volume of the fluid. Perfect compensation would require that upon a rise of temperature, the active area, and therefore the torsional effort, be augmented in the same ratio as viscosity is diminished. In other words, the percentage of decrease of viscosity divided by that of increase of area should be the same for all temperatures. Attention is called to the table below showing that, with mercury as the medium, the value of this fraction at ordinary temperatures is about, or not far from, 20.

Temperature °C	Volume of fluid	Viscosity of fluid	Percentage of increase of V.	Percentage of decrease of v.	Value of ratio.
T	V	v	a	b	$\frac{b}{a}$
-20	0.996364	0.018406	-0.3636	-8.2718	22.75
-15	0.997273	0.018038	-0.2727	-6.1029	22.38
-10	0.998182	0.017681	-0.1818	-4.0074	22.04
-5	0.999091	0.017335	-0.0909	-1.9722	21.70
0	1.000000	0.017000	0	0	21.35
5	1.000909	0.016663	0.0909	1.9107	21.02
10	1.001818	0.016361	0.1818	3.7603	20.68
15	1.002727	0.016057	0.2727	5.5505	20.35
20	1.003636	0.015762	0.3636	7.2706	20.00
25	1.004546	0.015477	0.4546	8.9584	19.70
30	1.005455	0.015202	0.5455	10.5750	19.38
35	1.006365	0.014937	0.6365	12.1410	19.07
40	1.007275	0.014680	0.7275	13.6470	18.75
45	1.008185	0.014433	0.8185	15.1031	18.45
50	1.009095	0.014194	0.9095	16.5073	18.15

当通过外部条件的变化或通过对流体所做的功,使流体的温度升高时,就会产生两种独立的和不同的效果。首先,黏附性按照一定的规律减小,相应地减小了扭矩,另一方面,流体膨胀,从而扩大了组件的活动表面或液体收缩表面的面积,结果是旋转力的增加。显然,如果有可能把这些作用关联起来,使它们在温度变化时相互抵消,就可以获得完全的补偿。我已经确定,这个结果几乎可以用一种液体(如水银)来完美地实现,方法是适当地调整被腔室容纳的或者正在施加补偿的液体组分 20c 和间隙 21 中的液体组分 20a 的体积比例。为了简化这种解释,假设力 F 完全是由液体组分 20a 引起的(施加在圆筒 12 底面上的拖动力可以

忽略不计，轴承无摩擦)。显然，在这些条件下，有效面积将随着流体体积的增加而增加。完美的补偿要求在温度升高时，有效面积和以及因此产生的扭转力以与黏附性降低的相同比例来增加。换句话说，在所有温度下，黏附性下降的百分比除以面积增加的百分比得到的结果应该是相同的。请注意下表，该表显示，以水银为介质，常温下该分数的值约为 20，或接近 20。

温度℃	流体体积	流体黏附性	体积增加百分比	黏附性减少百分比	比值
T	V	v	a	b	$\frac{b}{a}$
-20	0.996364	0.018406	-0.3636	-8.2718	22.75
-15	0.997273	0.018038	-0.2727	-6.1029	22.38
-10	0.998182	0.017681	-0.1818	-4.0074	22.04
-5	0.999091	0.017335	-0.0909	-1.9722	21.70
0	1.000000	0.017000	0	0	21.35
5	1.000909	0.016663	0.0909	1.9107	21.02
10	1.001818	0.016361	0.1818	3.7603	20.68
15	1.002727	0.016057	0.2727	5.5505	20.35
20	1.003636	0.015762	0.3636	7.2706	20.00
25	1.004546	0.015477	0.4546	8.9584	19.70
30	1.005455	0.015202	0.5455	10.5750	19.38
35	1.006365	0.014937	0.6365	12.1410	19.07
40	1.007275	0.014680	0.7275	13.6470	18.75
45	1.008185	0.014433	0.8185	15.1031	18.45
50	1.009095	0.014194	0.9095	16.5073	18.15

This means to say that if the total volume of the liquid is twenty times that contained in the interspace between the elements, the two opposite effects, one increasing and the other reducing, the torque, will approximately balance. This fact is borne out by practical tests and measurements, which have demonstrated that by constructing for this volumetric ratio deflections very closely proportionate to the speed are obtained through a range of temperature variations far greater than ordinarily occurring. For commercial purposes it is quite sufficient to employ a ratio of approximately the stated value as the error involved in a small departure therefrom is inconsiderable. When necessary or desirable, greater precision can be obtained by taking into account four secondary effects, due to expansion or contraction of the walls, which slightly modify the torque; first, changes in the volume of the reservoir; second, in the distance between the opposed surfaces; third, in active area and, fourth, in velocity. Increase in the former two tend to diminish, the latter to augment, the viscous drag. A satisfactory ratio in a cylindrical type of instrument has been found to be about 24.

这意味着，如果液体的总体积是组件之间的间隙所包含的体积的 20 倍，两个相反的效果，一个增加，另一个减少，扭矩将大致平衡。这一事实被实际的试验和测量所证实，这些试验和测量表明，通过构造这种体积比，可以通过远大于通常发生的温度变化范围获得与速度非常接近成比例的偏转。对于商业目的来说，采用近似于所述值的比率就足够了，因为微小的偏离所涉及的误差是微不足道的。当需要或希望时，可以通过考虑四个次要效应来获得更高的精度，这四个次要效应是由于壁的膨胀或收缩而略微改变扭矩；第一、容器体积的变化；

第二、面对面的表面之间的距离的变化；第三，在有效面积上的变化，第四，在速度上的变化。前两者的增加会减少黏附性拖动，而后者会增加黏附性拖动。已经发现，圆筒形仪器中令人满意的比值约为 24。

Fig. 5 illustrates a different arrangement, exemplifying the same principle of employing a reservoir-contained liquid body as the thermo-responsive means to compensate for viscosity changes of the active liquid. In this case a spindle-carried disk 12' serves as a secondary element, while the primary member consists of a hollow shell 10' with annular surfaces 23 confronting the disk surfaces and encompassed by an annular chamber 20', so that under rotation the mercury body fills the chamber and occupies peripheral portions of the interspaces 21 between the flat confronting surfaces. It is hardly necessary to remark that since there are two such interspaces 21, the calculation of capacity of the reservoir or chamber 20', beside considering the form of the device, must take account of the active mercury body in both interspaces.

图 5 展示了一个不同的布置，举例说明了采用一个容纳液体的容器作为热响应工具来补偿有效液体的黏附性变化的相同原理。在这种情况下，心轴承载的盘 12' 用作次级组件，而初级组件由空心壳体 10' 组成，该空心壳体 10' 具有面对盘表面的环形表面 23，并被环形腔室 20' 包围，从而在旋转下，水银填充腔室并占据平坦的面对面的表面之间的空隙 21 的外围部分。几乎没有必要注意到，由于有两个这样的空隙 21，除了考虑装置的形式之外，储存器或腔室 20' 的容量的计算必须考虑两个空隙中的有效水银的体积。

In Figs. 1 to 3 a complete commercial instrument embodying my invention is shown. Specifically, 25 is a tube threaded at 26 and carrying at the top a casing head 27 the whole forming a housing for enclosure of the moving parts. The driving shaft 28 carries a cylindrical cup 29 in the bottom of which is screwed a plug 30, turned down as 31 for the purpose of providing the reservoir 32. The cup 29 is closed at its upper end by a tight fitting cover 33, having an upwardly extending shank 34, carrying a pinion 35 to drive suitable wheelwork 36 of the odometer contained in the lower part of the head 27. This structure, providing the primary element, is rotatable in ball-bearings 37 and 38 fixed in tube 25 and adjustable by means of nuts 39.

在图 1 至 3 中，展示了体现我的发明的一个完整的商业工具。具体地说，25 是一根在 26 处有螺纹的管子，其顶部带有一个套管头 27，整体形成一个用于封闭运动部件的外壳。驱动轴 28 携带一个圆筒形杯 29，在其底部拧入一个塞子 30，为了形成容器 32，塞子 30 变细成 31。杯 29 在其上端由紧密贴合的盖 33 封闭，盖 33 具有向上延伸的柄 34，柄 34 带有小齿轮 35 以驱动里程表的合适的齿轮 36，它被容纳在头部 27 的较下部分中。提供主要组件的这种结构可在被固定在管 25 中的滚珠轴承 37 和 38 中旋转，并通过螺母 39 进行调节。

The secondary element is made of a very thin metal cup 40, inverted and secured to slender spindle 41 mounted in jeweled bearings 42 and 43, respectively carried in a cavity of plug 30 and by a frame arm 43'. A running bearing 42 can usually be employed without detriment, but a fixed bearing may be used if desired. The weight of the secondary member with its movable attachments should be so determined that the upward thrust against jewel 43 is very slight. The torsional twist of secondary cup 40 is resisted by a spiral spring 44 lodged in a turned recess of a frame plate 45, having one of its ends connected to collar 46 fast on the spindle 41 and the other to a split ring 47 spring-gripping the wall of the recess in plate 45. By inserting pincers in holes 48 (Fig. 5) and contracting the ring it is freed sufficiently for

adjustment to bring the spindle-carried indicator 49 to point to zero of the graduated scale 50 that, if all of the principles of my invention are best embodied, may be made uniformly graduated. The scale is carried on plate 45 and, together with the support 43', is held in place by a rim 53 that suitably carries the glass cover 52. The odometer may have any suitable number of indicating elements of different orders suitably geared, the two hands 54 and 55 sweeping over graduated dials 56 and 57, typifying any suitable construction.

次要组件由一个非常薄的金属杯 40 制成，倒置并固定到安装在宝石轴承 42 和 43 中的细长心轴 41 上，轴承 42 和 43 分别由塞子 30 的空腔和框架臂 43' 来承载。通常可以使用一个运转轴承 42 而不会造成损害，但是如果需要也可以使用一个固定轴承。具有可移动附件的次级部件的重量应该确定为使得对宝石 43 的向上推力非常轻微。次级杯体 40 的扭转被容纳在框架板 45 的一个转动壁凹中的螺旋弹簧 44 所抵抗，螺旋弹簧 44 的一端连接到紧固在轴 41 上的轴环 46 上，另一端连接到开口环 47，该开口环依靠弹力抓住在板 45 中的凹槽内壁。通过将钳子插入孔 48 中(图 5)并收缩开口环，环被充分地释放以进行调节，从而使心轴携带的指示器 49 指向刻度尺 50 的零点，如果我的发明的所有原理被最好地体现，则刻度尺 50 可以被制成均匀的刻度。刻度尺被承载在板 45 上，并且与支撑件 43' 一起被合适地承载玻璃盖 52 的边缘 53 固定到位。该里程表可以具有以不同规则适当啮合的任何适合数量的指示组件，两个指针 54 和 55 扫过刻度盘 56 和 57，这是任何适合结构的典型。

It will be apparent that the high torque at low speed developed through the mercurial transmitting medium makes the instrument very effective as one for use on automobiles, and while it is true that with a heavy fluid, as mercury, the range of velocity of the medium throughout which proportionality of torque to speed, under the described conditions, is rigorously linear falls below the range available where air is the medium, a construction presenting the friction surfaces of the elements in a cylinder-form as suggested in Figs. 2 and 4 permits of the use of a suitably constructed device with a small-diameter secondary to measure very high speeds without imparting to the medium a linear velocity beyond its stated range. For the successful use of mercury in the present described instrument (or other rotary devices) it is important that the mercury be pure, the surfaces contacting therewith smooth, clean and non-granular (preferably nickel-plated or made of non-corrosive, high grade steel) to minimize abrasion and keep the mercury clean, and that the linear velocity of the mercury be kept low, preferably below six feet per second, in order that it may not break up into minute droplets or apparently-powdered form.

很明显，通过水银传输介质在低速下产生的高扭矩使得该仪器作为用于汽车上的仪器非常有效，并且尽管事实上对于像水银这样的重流体，在所述条件下，扭矩与速度成严格线性比例的介质速度范围低于空气作为介质的可用范围，如图 2 和图 4 所示的在圆筒形组件中的摩擦表面的结构允许使用具有小直径次级组件的适当构造的装置来测量非常高的速度，而不会使介质的线速度超过其所述的范围。为了在当前描述的仪器（或其他旋转装置）中成功使用水银，重要的是水银是纯净的，与其接触的表面是光滑的、清洁的和非颗粒状的（优选镀镍的或由不锈钢的高级钢制成），能最小化磨损并保持水银清洁，并且水银的线速度保持低速，最好低于每秒 6 英尺，以便它不会分裂成微小的液滴或明显的粉末形式。

What I claim is:

我主张的是：

1. In combination, driving and driven elements, having opposed, closely-adjacent, non-contacting friction surfaces; a liquid body interposed between active areas thereof through which the driving element frictionally drags the driven one and thermo-responsive means for varying the active area of the secondary in approximately inverse proportion to the thermo-effected variations in viscosity of the liquid.

1、存在一个组合，包括：具有面对面的、紧密相邻的、非接触的摩擦表面的驱动组件和从动组件；一种介入这两个组件的有效面积之间的液体，驱动组件通过该液体摩擦拖动从动组件；以及一个热响应工具，该热响应工具用于按照与液体黏附性的热效应变化近似成反比的关系来改变次级组件的有效面积。

2. In a temperature-compensating speed indicator, the combination of variable speed primary and movement-restrained secondary elements that are suitably supported for separate movement and have opposed friction surfaces in close but non-contacting juxtaposition; an interposed liquid body contacting normally with active areas of said surfaces less than the whole thereof, and thermo-responsive means for varying the liquid-contacting areas of said elements approximately inversely to the thermo-effected variations of liquid viscosity.

2、在一个温度补偿的速度指示器中，存在一个组合，包括：变速初级组件和运动受限次级组件，它们被适当地支撑以进行独立的运动，并具有紧密但非接触的、并排的、面对面的摩擦表面；介于表面之间的液体，通常与所述表面的有效区域接触，而不是整个有效区域；以及热响应工具，用于改变所述组件的液体接触面积，该面积与液体黏附性的热效应变化近似相反。

3. In a temperature-compensating speed indicator, the combination of variable speed primary and movement-restrained secondary elements that are suitably supported for separate movement and have opposed closely-adjacent non-contacting friction surfaces; an interposed liquid body and thermo-responsive means for varying the active areas of said surfaces in predetermined proportion to thermally-effected changes of liquid viscosity.

3、在一个温度补偿的速度指示器中，存在一个组合，包括：速度可变的初级组件和运动受限的次级组件，它们被适当地支撑以独立运动，并具有面对面的紧密相邻的非接触摩擦表面；介入表面之间的液体；以及热响应工具，该工具用于根据液体黏附性的热效应变化以预定的比例关系改变所述表面的有效面积。

4. In a temperature-compensating speed indicator, the combination of variable speed primary and movement-restrained secondary elements that are suitably supported for separate movement and have opposed closely-adjacent non-contacting friction surfaces; a liquid body partially filling the interspace between said surfaces, and thermo-responsive means for varying the liquid quantity within in said interspace in predetermined inverse ratio to thermo-effected changes of liquid viscosity.

4、在一个温度补偿的速度指示器中，存在一个组合，包括：速度可变的初级组件和运动受限的次级组件，它们被适当地支撑以独立运动，并具有面对面的紧密相邻的非接触摩擦表面；一种液体部分地填充所述表面之间的间隙；以及热敏装置，用于以与液体黏附性的热影响变化成预定反比的方式改变所述间隙中的液体量。

5. The combination with driving and driven elements having opposed, closely-adjacent, non-contacting friction surfaces and an interposed liquid body contacting with active portions thereof, of a compensating liquid body communication with the said interposed or active one, and proportioned to vary the effective contact area of the active liquid approximately inversely to its temperature-effected viscosity changes.

5、存在一个组合，包括：具有面对面的、紧密相邻的、非接触的摩擦表面的驱动组件和从动组件；介入这些组件之间并与它们的有效部分接触的液体；补偿液体与所述介入的或者活性的液体连通，并成比例地改变活性液体的有效接触面积，大致与其受温度影响的黏附性变化成反比。

6. The combination with freely movable driving and movement-resisted driven elements, having friction surfaces in opposed, closely-adjacent non-contacting relation, of means providing a reservoir, communicating with the interspace between said elements, and a liquid body having a reservoir-filling component and an active torque-transmitting component that normally, partly occupies said interspace, these components proportioned volumetrically for temperature-effected change of the contact area of the active component in approximately inverse ratio to the attendant changes of liquid viscosity.

6、存在一个组合，包括：自由移动的驱动部件和阻止运动的从动部件，它们具有面对面的、紧密相邻的非接触关系的摩擦表面；提供与所述部件之间的间隙连通的贮液器的装置；以及具有能填充贮液器的部件的液体和通常部分地占据所述间隙的主动传递扭矩的部件，这些部件的体积变化与主动部件的接触面积的温度影响的变化成比例，与伴随的液体黏附性的变化近似成反比。

7. In a temperature-compensating speed indicator, the combination of a freely rotatable cylindrical cup; a cylinder-formed member in the upper portion thereof, pivoted and spring-restrained; and a body of mercury filling the reservoir-portion of the cup below the pivoted member and extending partially in the narrow interspace between the cup and cylinder.

7、在一个温度补偿速度指示器中，存在一个组合，包括：一个可自由旋转的圆筒杯；在其上部中的一个圆柱形构件，被枢转并受弹簧约束；以及填充被枢转构件下方的杯子的贮存部分的水银体，并部分地在杯子和圆筒之间的狭窄间隙中延伸。

In testimony whereof I affix my signature.

我签名为证。

NIKOLA TESLA.

尼古拉·特斯拉

N. TESLA.
SPEED INDICATOR.
APPLICATION FILED DEC. 18, 1916.

1,274,816.

Patented Aug. 6, 1918.

Fig. 1.

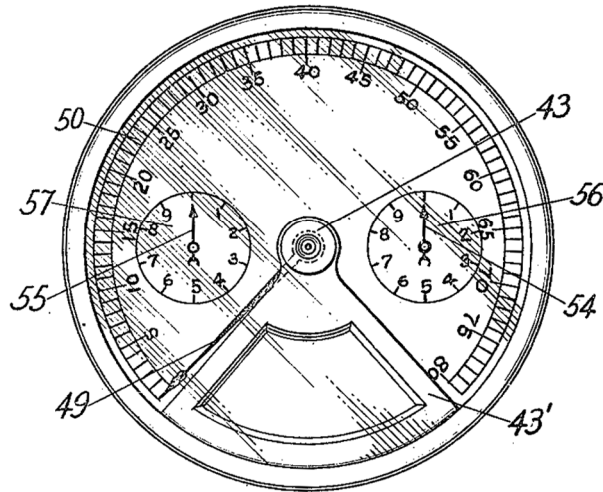


Fig. 3.

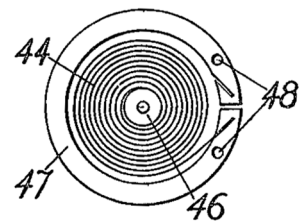


Fig. 2.

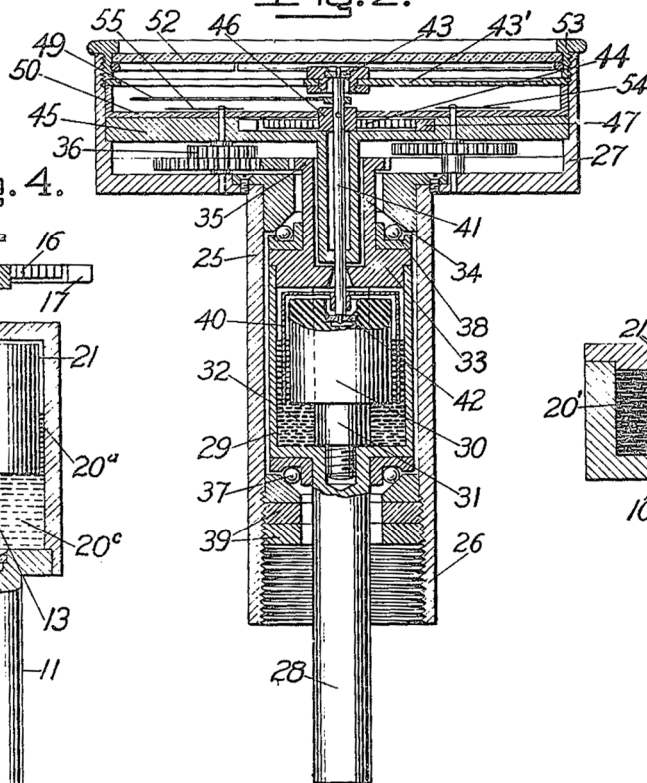


Fig. 4.

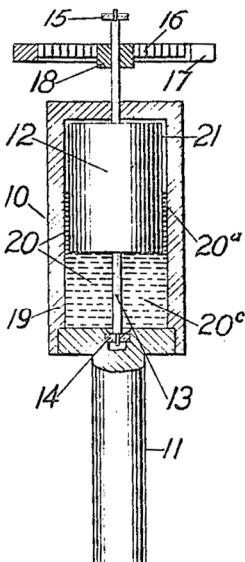
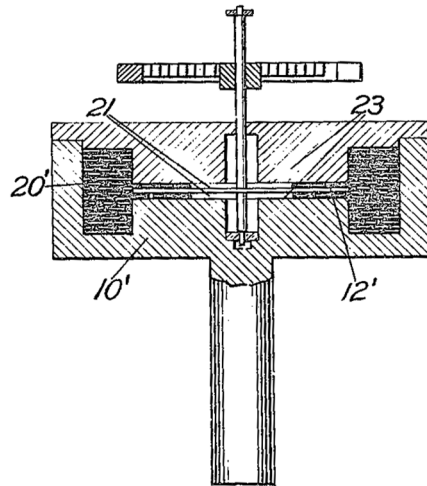


Fig. 5.



Inventor
Nikola Tesla
By his Attorneys
Foré Bain & May

SHIP'S LOG.

船舶测速仪

NIKOLA TESLA, OF NEW YORK, N. Y., ASSIGNOR TO WALTHAM WATCH COMPANY,
OF WALTHAM, MASSACHUSETTS, A CORPORATION OF MASSACHUSETTS.

纽约州纽约市的尼古拉·特斯拉，将专利权转让给马萨诸塞州沃尔瑟姆市的
沃尔瑟姆钟表公司，它是马萨诸塞州的一家公司。

1,314,718. Specification of Letters Patent. Patented Sept. 2, 1919.

Application filed December 18, 1916. Serial No. 137,690.

专利证书说明书第 1,314,718 号。在 1919 年 9 月 2 日被授予专利。

申请于 1916 年 12 月 18 日。序列号为 137,690。

To all whom it may concern:

致所有相关人士：

Be it known that I, NIKOLA TESLA, a citizen of the United States, residing at New York, in the county and State of New York, have invented certain new and useful Improvements in Ship's Logs, of which the following is a full, clear, and exact description.

众所周知，我、尼古拉·特斯拉，一位美国公民，居住在纽约州纽约郡纽约市，在船舶测速仪方面已经发明了某些新的和有用的改进，以下是该发明一个完整的、清晰的和准确的描述。

My invention provides a ship's log of novel and advantageous construction and operation, designed to give instantaneous rate-readings, as in knots, or miles per hour. The customary log is trailed astern, twisting the flexible connector that drives a revolution-counter on the vessel, and many disadvantages of such arrangement are obvious.

我的发明提供了一种具有新颖的和有优势的结构和操作的船舶测速仪，被设计用于给出瞬时速率读数，如每小时的节数或英里数。传统的计程仪被拖在船尾，这扭曲了驱动船舶上的旋转计数器的柔性连接器，这种布置的许多缺点是显而易见的。

In my instrument I combine very advantageously a propeller rotatable proportionately to vessel-speed and a speed indicator driven by it and reading directly in the desired terms, preferably upon a substantially uniformly-graduated scale.

在我的仪器中，我非常有优势地结合了与船速成正比的可旋转的推进器和由其驱动的速度指示器，该指示器直接以预期的方式读数，最好在刻度基本上均匀的标尺上。

In the drawings, Figure 1 diagrams the log in use; Fig. 2 shows it in vertical section; Fig. 3 illustrates speed-indicator parts with the casing broken away; Fig. 4 is a section on line 4—4 of Fig. 3; Fig. 5 is a

section on line 5—5 of Fig. 2. Fig. 6 shows in section a turbine form of propeller, and Fig. 7 is a section on line 7—7 of Fig. 6.

在附图中，图 1 展示了使用中的船舶测速仪；图 2 是垂直截面图；图 3 展示了壳体被剖开的速度指示器部件；图 4 是在图 3 的线 4-4 上的截面图；图 5 是在图 2 的线 5-5 的截面图。图 6 展示了螺旋桨的涡轮机形式的截面图，图 7 是沿图 6 的线 7-7 的截面图。

To the vessel 10, preferably near its bow, is suitably affixed a tube or barrel, 11, with a threaded plug 12 closing its lower end, where the tube preferably dips below the level of the boat's keel. At the top—near the deck or other point of observation—the speed-indicator 13 is mounted, its casing 14, that carries all of the moving parts being detachably secured, as by screws 15, to the top-flange 16 of the barrel. A boss 17 on the underside of casing 14 supports the ball bearing 18 for the primary element of the indicator and a seal 19 for its flexible driveshaft 20 that connects preferably through a slip-joint squared union, 21, to a propeller-driven part. The propeller may be of common form as shown in Fig. 2, at 22, with its shaft 23 horizontally mounted in the bracket 24 spanning the tubular passage 25 of a housing 26 that fits neatly in the barrel and is held in register with ports 27 and 28 by guide-ribs 29. Such a propeller drives the shaft 20 through bevel gears 30.

在船 10 上，最好靠近船首，适当地附加上一根管子或圆筒 11，用一个螺纹塞 12 封闭其下端，管子最好低于船的龙骨高度。在顶部——靠近甲板或其它观察点——安装有速度指示器 13，其壳体 14 承载所有可移动部件，并通过螺钉 15 可拆卸地固定到圆筒的顶部凸缘 16 上。外壳 14 下侧上的凸出 17 支撑着用于指示器主要组件的滚珠轴承 18 和用于柔性驱动轴 20 的密封件 19，该柔性驱动轴 20 首选通过一个滑动接合方形接头 21 连接到一个螺旋桨推动部分。螺旋桨可以是如图 2 中 22 所示的普通形式，其轴 23 水平安装在支架 24 上，支架 24 横跨外壳 26 的管状通道 25，壳体 26 整齐地安装在圆筒中，并通过导向肋片 29 保持与端口 27 和 28 对齐。这种螺旋桨通过锥齿轮 30 来驱动轴 20。

More advantageously in some respects, however, a turbine propeller of simple construction may be employed, as shown in Figs. 6 and 7. The rotor in this instance has a vertical shaft 23' and the wheel 22' is formed of thin, parallel, closely-spaced disks each having a central opening. The wheel is arranged in a cylindrical housing 26' that has inlet nozzles 31 and outlet ports 32 so disposed that the water enters the interspaces between the disks tangentially to rotate the wheel and finds escape through the ports 32 that communicate with the central orifices of the disks. This type of construction has many advantages due to its reliability and efficiency, but preferable it should be constructed to permit the disks and casing 26' being made in two horizontal sections bolted together as at 33, each section having a detachable head 34.

然而，在某些方面更有优势的是，可以采用结构简单的涡轮螺旋桨，如图 6 和 7 所示。在这种情况下，转子具有垂直轴 23' 和由薄的、平行的、紧密间隔的圆盘组成的转轮 22'，每个圆盘具有一个中心开口。转轮被布置在圆柱形外壳 26' 中，该外壳具有入口喷嘴 31 和出口端口 32，出口端口 32 被布置成使得水沿着切向方向进入圆盘之间的空隙以旋转转轮，并通过与圆盘的中心孔连通的端口 32 找到出口。这种类型的结构由于其可靠性和效率而具有许多优点，但是首选地，它应该被构造成允许圆盘和外壳容易清洁，外壳 26' 被制成在 33 处栓接在一起的两个水平部分，每个部分具有一个可拆卸的头部 34。

A flexible and longitudinally elastic sleeve, 35, of coiled strip metal is fastened at opposite ends by threaded caps 36 and 37 to the boss 17 and to a threaded part on the propeller casing, so that the propeller mechanism is supported from the indicator casing for removal therewith.

由盘绕的带状金属制成的具有柔性和纵向弹性的套筒 35 被螺纹盖 36 和 37 在相对端紧固到凸出 17 和螺旋桨外壳上的螺纹部分，使得螺旋桨机械结构由指示器外壳支撑，以便与其一起移除。

By suitably constructing the submerged parts of bronze, enameling them, or otherwise making them substantially immune to corrosion, adequate durability is attained, and the facility of removal for cleaning, oiling, repairs, etc., makes the under-water parts easy to maintain in good order. The pliant shaft, slip-connected at one end and its stout protective sleeve, strong yet flexible and extensible frees the bearings from strain and makes the connection uniformly efficient under changes of conditions as to temperature, etc.

通过适当地构造浸没在水中的青铜部件，给它们上釉，或以其他方式使它们基本上不受腐蚀，获得了足够的耐久性，并且便于移除以进行清洁、涂油、修理等，使得水下部件易于保持良好的状态。一端滑动连接的易弯曲轴及其坚固的保护套筒，坚固而灵活且可延伸，使轴承免受应变，并使该连接在温度等条件变化下一致有效。

The speed indicator 13 preferably provides as its primary element 41 a multiple-walled cup, fast on shaft 20, and as a secondary, or indication-giving, member a lightly-constructed pivoted, multiple-walled inverted cup structure 42, with the annular walls interleaved in closely adjacent non-contacting relation for transmission of turning effort from the one to the other through intervening films of the casing-contained fluid medium, as air, in approximately linear proportion to the speed of the primary. Specifically the secondary cups are dependent from an arm 43 projecting from spindle 44, having jewel bearings in yoke 45 carried by bridge-piece, 46, that spans the casing 14, and the dial 47, calibrated according to a suitable constant to read in knots, or miles per hour or other units of rate, is borne by the cup-structure below a fixed hand 48 visible through the sealed cover-glass 49. A coiled spring 50, connected at its ends respectively to the pivoted secondary element and to a fixed support, resists the pivotal displacement of the indication-giving member. The light secondary element, quickly and accurately responsive approximately directly proportionately to the speed of the propeller-driven primary member, and little affected by tremors, temperature changes and other extraneous influences, gives adequately accurate readings in the desired terms, showing instantaneously changes of the vessel's speed.

速度指示器 13 最好提供紧固在轴 20 上的多壁杯作为其初级组件 41，以及作为次级组件或给出指示的部件的一个轻型结构的被枢转的多壁倒置杯结构 42，其环形壁是紧密相邻的非接触关系交错，用于利用被外壳所容纳的流体介质（例如空气）的介入薄层将旋转力从一个传递到另一个，与初级组件的速度近似成线性比例。具体地说，次级杯依赖于从心轴 44 突出的臂 43，心轴 44 在轭 45 中具有宝石轴承，轭 45 由横跨外壳 14 的桥接件 46 承载，刻度盘 47 由一个固定指针 48 下方的杯状结构支撑，通过密封的玻璃盖 49 可以看到固定指针 48，刻度盘 47 根据适合的常数校准以读取每小时节数、英里数或其它速率单位。螺旋弹簧 50 在其端部分别连接到被枢转的次级组件和一个固定的支撑件，阻碍着指示给出部件的枢转位移。轻的次级组件快速且准确地响应由螺旋桨驱动的初级组件的速度，几乎不受震动、温度

变化和其他外来因素的影响，以预期的方式给出足够准确的读数，显示出船舶速度的瞬时变化。

What I claim is:

我主张的是：

1. In ship's log, a barrel having water flow openings near its bottom, a speed-indicator detachably secured to one end of the barrel, a flexible shaft for the speed-indicator, a propeller connected to the shaft-end, a housing for the propeller, registering with the water-flow openings, and a sleeve surrounding the shaft uniting the housing and casing, for extraction of the propeller-parts when the speed-indicator is removed from the barrel.

1、在船舶测速仪中，有一个圆筒，其底部附近具有水流开口；一个速度指示器，它被可拆卸地固定到圆筒的一端；用于速度指示器的一个柔性轴；连接到该轴端的一个螺旋桨；与水流开口对准的螺旋桨外壳；以及围绕轴的连接着外壳和壳体的套筒，用于当速度指示器从圆筒移除时抽出螺旋桨部件。

2. In a ship's log, a barrel, a speed indicator having a casing secured detachably to the upper or observation end of the barrel, a propeller having a housing and adapted to pass through the barrel, a flexible shaft slip-fitted to connect the propeller and speed indicator, and a flexible sleeve connecting the propeller-housing and indicator-casing.

2、在一个船舶测速仪中，有一个圆筒；一个速度指示器，它具有可拆卸的被固定在圆筒的上端或观察端的外壳；具有外壳并适于穿过该圆筒的一个螺旋桨；一个滑动配合以连接螺旋桨和速度指示器的柔性轴；以及一个连接推进器外壳和指示器外壳的柔性套筒。

3. In a ship's log, the combination of a barrel having waterflow openings near its bottom, a speed indicator having a casing detachably secured to one end of the barrel, a shaft for said speed indicator extending centrally through the barrel, a propeller for the shaft end, a housing for the propeller, said housing being smaller than the barrel, and a sleeve surrounding the shaft uniting said housing and said indicator casing for effecting extraction of the propeller parts when the speed indicator is removed from the barrel.

3、在一个船舶测速仪中，存在一个组合，包括：一个圆筒，其底部附近具有水流开口；一个速度指示器，具有可拆卸地固定到圆筒的一端的外壳；用于所述速度指示器的一个轴，在中心延伸穿过圆筒；用在轴端的螺旋桨；用于螺旋桨的一个外壳，所述外壳小于圆筒；以及围绕轴的一个套筒，该套筒结合所述外壳和所述指示器外壳，用于当速度指示器从圆筒移除时抽出螺旋桨部件。

4. In a ship's log, a barrel, a speed indicator having a casing secured detachably to the upper end of the barrel, a propeller having a housing and adapted to pass through the barrel, there being registering openings near the bottom of the barrel and in said housing for water-flow to the propeller, a flexible shaft connecting said propeller and speed indicator and making axially slidable connection with one thereof, and a flexible and axially expansible sleeve connecting the propeller housing and the indicator

casing for extraction of the propeller parts when the speed indicator is removed from the barrel.

4、在一个船舶测速仪中，有一个圆筒；一个速度指示器，具有可拆卸地固定在圆筒上端的外壳；一个具有外壳并适于穿过圆筒的螺旋桨；在圆筒底部附近和所述外壳中有相互对准的开口，用于使水流到螺旋桨；连接所述推进器和速度指示器并与它们中的一个进行轴向滑动连接的一个柔性轴；以及连接螺旋桨外壳和指示器外壳的柔性的且轴向可膨胀的套筒，用于当速度指示器从圆筒上取下时取出螺旋桨部件。

In testimony whereof I affix my signature.

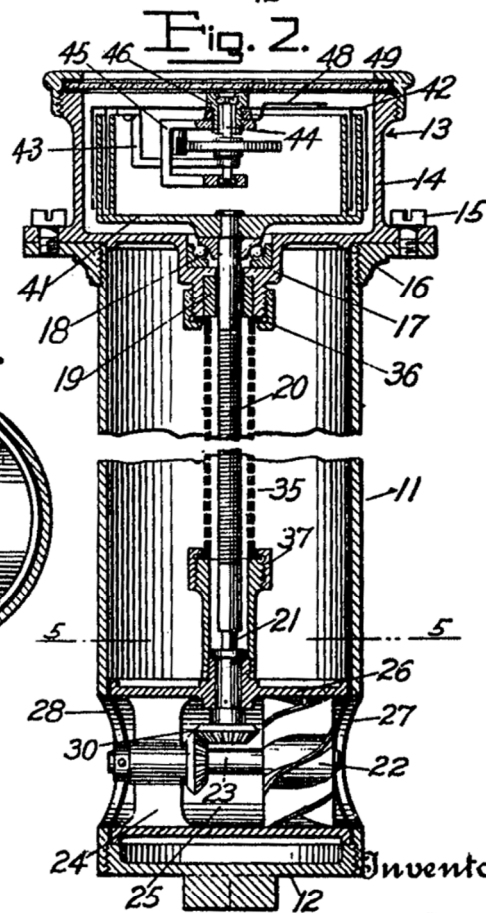
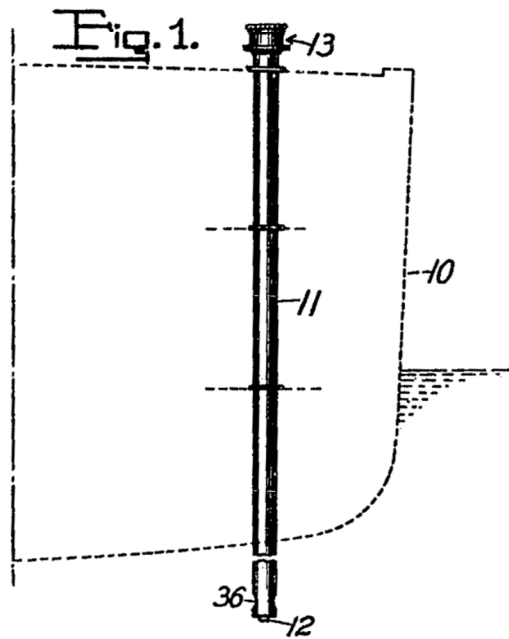
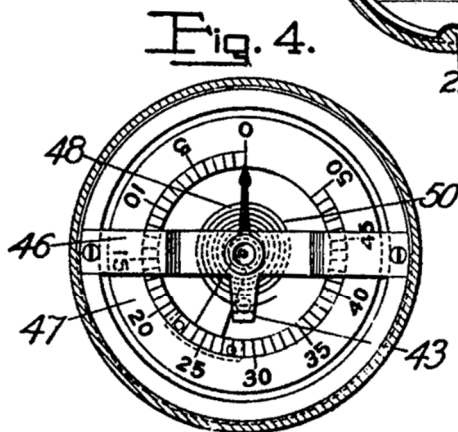
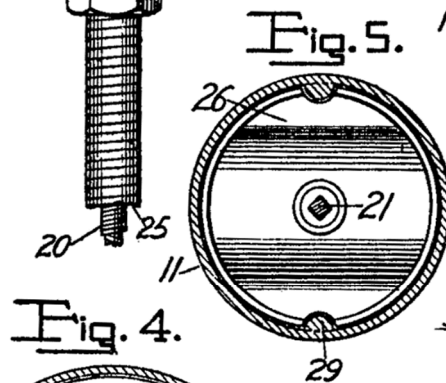
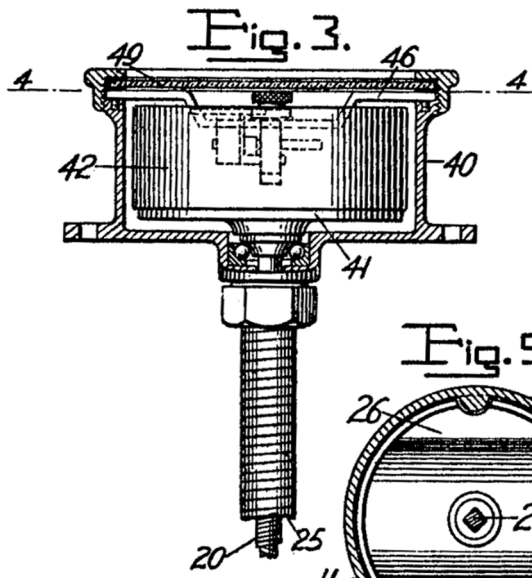
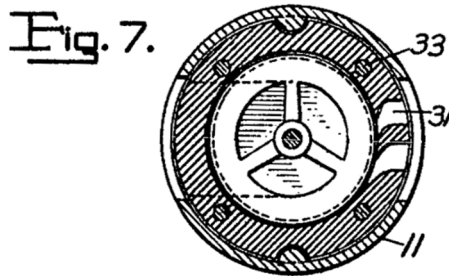
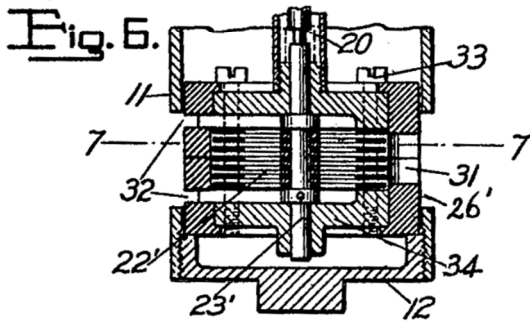
我签名为证。

NIKOLA TESLA.

尼古拉·特斯拉

Patented Sept. 2, 1919.

1,314,718.



Inventor
By his Attorneys Nikola Tesla
Goree Rainshay

VALVULAR CONDUIT.

瓣膜式导管

NIKOLA TESLA, OF NEW YORK, N. Y.

纽约州纽约市的尼古拉·特斯拉

1,329,559. Specification of Letters Patent. Patented Feb. 3, 1920.

Application filed February 21, 1916, Serial No. 79,703.

Renewed July 8, 1919. Serial No. 309,482.

专利证书说明书第 1,329,559 号。在 1920 年 2 月 3 日被授予专利。

申请于 1916 年 2 月 21 日。序列号为 79,703。

更新于 1919 年 7 月 8 日。序列号为 309,482。

To all whom it may concern:

致所有相关人士:

Be it known that I, NIKOLA TESLA, a citizen of the United States, residing at New York, in the county and State of New York, have invented certain new and useful Improvements in Valvular Conduits, of which the following is a full, clear, and exact description.

众所周知，我，尼古拉·特斯拉，一位美国公民，居住在纽约州纽约郡纽约市，在瓣膜式导管方面已经发明了某些新的和有用的改进，以下是该发明一个完整的、清晰的和准确的描述。

In most of the machinery universally employed for the development, transmission and transformation of mechanical energy, fluid impulses are made to pass, more or less freely, through suitable channels or conduits in one direction while their return is effectively checked or entirely prevented. This function is generally performed by devices designated as valves, comprising carefully fitted members the precise relative movements of which are essential to the efficient and reliable operation of the apparatus. The necessity of, and absolute dependence on these, limits the machine in many respects, detracting from its practical value and adding greatly to its cost of manufacture and maintenance. As a rule the valve is a delicate contrivance, very liable to wear and get out of order and thereby imperil ponderous, complex and costly mechanism and, moreover, it fails to meet the requirements when the impulses are extremely sudden or rapid in succession and the fluid is highly heated or corrosive.

在大多数普遍用于机械能的产生、传递和转换的机械中，流体脉冲或多或少自由地沿一个方向通过适合的通道或导管，而它们的返回被有效地阻挡或完全阻止。该功能通常由称为阀门的装置来执行，该装置包括精心装配的部件，这些部件的精确相对运动对于设备的有效的和可靠的操作是必不可少的。这些部件的精确相对运动的必要性和对此的绝对依赖性在许多方面限制了机器，降低了机器的实用价值，并大大增加了它的制造成本和维护成本。一般说来，阀门是一种精密的装置，很容易磨损和发生故障，从而危及笨重、复杂和昂贵的机器，而且，当脉冲极其突然或快速连续并且流体高度受热或具有腐蚀性时，阀门就难以满足要求。

Though these and other correlated facts were known to the very earliest pioneers in the science and art of mechanics, no remedy has yet been found or proposed to date so far as I am aware, and I believe that I am the first to discover or invent any means, which permit the performance of the above function without the use of moving parts, and which it is the object of this application to describe.

虽然这些和其他相关的事实是力学的科学和技术中的最早的先驱所知道的,但据我所知,迄今为止还没有发现或提出任何补救措施,我相信我是第一个发现或发明任何一种工具的人,这些工具允许在不使用移动部件的情况下执行上述功能,并且这是本申请描述的目的。

Briefly expressed, the advance I have achieved consists in the employment of a peculiar channel or conduit characterized by valvular action.

简单地说,我所取得的进步在于采用了一种特殊的以瓣膜作用为特征的通道或导管。

The invention can be embodied in many constructions greatly varied in detail, but for the explanation of the underlying principle it may be broadly stated that the interior of the conduit is provided with enlargements, recesses, projections, baffles or buckets which, while offering virtually no resistance to the passage of the fluid in one direction, other than surface friction, constitute an almost impassable barrier to its flow in the opposite sense by reason of the more or less sudden expansions, contractions, deflections, reversals of direction, stops and starts and attendant rapidly succeeding transformations of the pressure and velocity energies.

本发明可以在细节上有很大变化的许多结构中实施,但是为了解释基本原理,可以概括地说,导管的内部设置有扩大部、壁凹部、突出部、折流部或斗部,除了表面摩擦之外,它们实际上对流体在一个方向上的通过没有阻力,但是由于或多或少的突然的膨胀、收缩、偏转、方向逆转、停止和启动以及随之而来的压力和速度能量的快速转换,它们对流体在相反方向上的流动构成了几乎不可逾越的障碍。

For the full and complete disclosure of the device and of its mode of action reference is made to the accompanying drawings in which—

为了充分和完整地公开该装置及其作用模式,请参考附图,其中—

Figure 1 is a horizontal projection of such a valvular conduit with the top plate removed.

图 1 是移除了顶板的这种瓣膜导管的水平投影。

Fig. 2 is side view of the same in elevation.

图 2 是其侧视图。

Fig. 3 is a diagram illustrative of the application of the device to a fluid propelling machine such as, a reciprocating pump or compressor, and Fig. 4 is a plan showing the manner in which the invention is, or may be used, to operate a fluid propelled rotary engine or turbine.

图 3 是说明该装置应用于流体推进机器（如往复泵或压缩机）的示意图，图 4 是展示本发明用于或可能用于操作流体推进的旋转引擎或涡轮机的方式的平面图。

Referring to Fig. 1, 1 is a casing of metal or other suitable material which may be cast, milled or pressed from sheet in the desired form. From its side-walls extend alternatively projections terminating in buckets 2 which, to facilitate manufacture are congruent and spaced at equal distances, but need not be. In addition to these there are independent partitions 3 which are deemed of advantage and the purpose of which will be made clear. Nipples 4 and 5, one at each end, are provided for pipe connection. The bottom is solid and the upper or open side is closed by a fitting plate 6 as shown in Fig. 2. When desired any number of such pieces may be joined in series, thus making up a valvular conduit of such length as the circumstances may require.

参考图 1，1 是金属或其他合适材料的外壳，这种外壳可以由薄板铸造、铣削或压制所需的形式。从其侧壁交替地延伸出终止于斗部 2 的突出部，为了便于制造，这些突出部是全等的并且以相等的距离间隔开，但这不是必须的。除了这些之外，还有独立的隔板 3，这些隔板被认为是具有优势的，其目的将被阐明。管接头 4 和 5，每端一个，用于管道连接。底部是实心的，上侧或开口侧由一个装配板 6 封闭，如图 2 所示。当需要时，可以将任意数量的这种部件串联起来，从而根据情况的需要组成一个这种长度的瓣膜导管。

In elucidation of the mode of operation let it be assumed that the medium under pressure be admitted at 5. Evidently, its approximate path will be as indicated by the dotted line 7, which is nearly straight, that is to say, if the channel be of adequate cross-section, the fluid will encounter a very small resistance and pass through freely and undisturbed, at least to a degree. Not so if the entrance be at the opposite end 4. In this case the flow will not be smooth and continues, but intermittent, the fluid being quickly deflected and reversed in direction, set in whirling motion, brought to rest and again accelerated, these processes following one another in rapid succession. The partitions 3 serve to direct the stream upon the buckets and to intensify the actions causing violent surges and eddies which interfere very materially with the flow through the conduit. It will be readily observed that the resistance offered to the passage of the medium will be considerable even if it be under constant pressure, but the impediments will be of full effect only when it is supplied in pulses and, more especially, when the same are extremely sudden and of high frequency. In order to bring the fluid masses to rest and to high velocity in short intervals of time energy must be furnished at a rate which is unattainable, the result being that the impulse cannot penetrate very far before it subsides and gives rise to movement in the opposite direction. The device not only acts as a hinderment to the bodily return of particles but also, in a measure, as a check to the propagation of a disturbance through the medium. Its efficacy is chiefly determined; first, by the magnitude of the ratio of the two resistances offered to disturbed and to undisturbed flow, respectively, in the directions from 4 to 5 and from 5 to 4, in each individual element of the conduit; second, by the number of complete cycles of action taking place in a given length of the valvular channel and, third, by the character of the impulses themselves. A fair idea may be gained from simple theoretical considerations.

在说明操作模式时，假设压力介质在 5 处进入。显然，其近似路径将如虚线 7 所示，几乎是直的，也就是说，如果通道具有足够的横截面，流体将遇到非常小的阻力，并且至少在一定程度上自由且不受干扰地通过。如果入口在相对端 4 处，则不是这样。在这种情况下，流动将不是平稳和连续的，而是间歇性的，流体被快速偏转和反转，被设置在旋转运动中，停止

下来并再次加速，这些过程快速地承继。隔板 3 用于将水流引导到斗部上，并加强引起剧烈浪涌和涡流的作用，这些浪涌和涡流严重干扰了通过导管的流动。很容易观察到，对介质的通行的阻力将是相当大的，即使介质是在恒定的压力下，阻力也将是相当大的，但只有当介质以脉冲供应时，这种阻碍将是完全有效的，特别是当这种阻碍同样也是非常突然和高频率。为了使流体物质停止并在短时间间隔内达到高速，必须以一个难以达到的速度提供能量，其结果是脉冲在平息之前不能穿透很远，并且引起相反方向的运动。该装置不仅作为粒子返回的障碍物，而且在某种程度上，作为对扰动通过介质的传播的一种抑制。其功效主要取决于：首先，在导管的每个单独组件中，分别在从 4 到 5 和从 5 到 4 的方向上，通过提供给受扰流和未受扰流的两个阻力的比率的大小；其次，在一个给定长度的瓣膜通道中发生的完整动作循环的数量，最后，脉冲本身的特征。从简单的理论考虑中可以得到一个合理的想法。

Examining more closely the mode of operation it will be seen that, in passing from one to the next bucket in the direction of disturbed flow, the fluid undergoes two complete reversals or deflections through 180 degrees while it suffers only two small deviations from about 10 to 20 degrees when moving in the opposite sense. In each case the loss of head will be proportionate to a hydraulic coefficient dependent on the angle of deflection from which it follows that, for the same velocity, the ratio of the two resistances will be as that of the two coefficients. The theoretical value of this ratio may be 200 or more, but must be taken as appreciably less although the surface friction too is greater in the direction of disturbed flow. In order to keep it as large as possible, sharp bends should be avoided, for these will add to both resistances and reduce the efficiency. Whenever practicable, the piece should be straight; the next best is the circular form.

更仔细地检查操作模式，将会看到，在受干扰的流动方向上从一个斗部到下一个斗部的过程中，流体经历两次 180 度的完全反向或偏转，而在相反方向上运动时，流体仅经历两次大约 10 至 20 度的小偏转。在每种情况下，水头损失将与取决于偏转角度的水力系数成比例，由此可以得出，对于相同的速度，两个阻力的比率将与两个系数的比率相同。这个比值的理论值可能是 200 或更大，但必须取为明显更小的值，尽管表面摩擦在受干扰的流动方向上更大。为了比值尽可能大，应避免尖锐的结合，因为这会增加阻力并降低效率。只要可行，器件应该是直的；下一个最好的是圆形。

That the peculiar function of such a conduit is enhanced by increasing the number of buckets or elements and, consequently, cyclic processes in a given length is an obvious conclusion, but there is no direct proportionality because the successive actions diminish in intensity. Definite limits, however, are set constructively and otherwise to the number of elements per unit length of the channel, and the most economical design can only be evolved through long experience.

通过增加斗部或组件的数量，这种管道的特殊功能得到增强，因此，在给定长度内的循环过程是一个显而易见的结论，但是没有直接的成比例关系，因为承继作用在强度上减弱。然而，对通道每单位长度的组件数量的明确限制是建设性地设置的，否则，最经济的设计只能通过长期的经验来逐渐发展。

Quite apart from any mechanical features of the device the character of the impulses has a decided influence on its performance and the best results will be secured, when there are produced at 4, sudden variations of pressure in relatively long intervals, while a constant pressure is maintained at 5. Such is the case in one of its most valuable industrial applications which will be specifically described.

除了该装置的任何机械特征之外，脉冲的特征对其性能具有决定性的影响，并且当在 4 处产生在相对长时间间隔内的突然的压力变化，而在 5 处保持恒定压力时，这将是获得的最佳结果。这是其最有价值的工业应用之一的情况，将具体描述。

In order to conduce to a better understanding, reference may first be made to Fig. 3 which illustrates another special use and in which 8 is a piston fixed to a shaft 9 and fitting freely in a cylinder 10. The latter is closed at both ends by flanged heads 11 and 12 having sleeves or stuffing boxes 13 and 14 for the shaft. Connection between the two compartments, 15 and 16, of the cylinder is established through a valvular conduit and each of the heads is similarly equipped. For the sake of simplicity these devices are diagrammatically shown, the solid arrows indicating the direction of undisturbed flow. An extension of the shaft 9 carries a second piston 17 accurately ground to and sliding easily in a cylinder 18 closed at the ends by plates and sleeves as usual. Both piston and cylinder are provided with inlet and outlet ports marked, respectively, 19 and 20. This arrangement is familiar, being representative of a prime mover of my invention, termed “mechanical oscillator”, with which it is practicable to vibrate a system of considerable weight many thousand times per minute.

为了有助于更好的理解，可以首先参考图 3，图 3 展示了另一种特殊用途，其中 8 是固定到轴 9 上并自由装配在气缸 10 中的活塞。后者的两端被弯边封头 11 和 12 封闭，该弯边封头具有用于轴的套筒或填料函 13 和 14。气缸的两个隔室 15 和 16 之间的连接通过一个瓣膜导管建立，并且每个气缸盖都类似地装备。为了简单起见，这些装置用图解法表示，实线箭头表示未受干扰的流动方向。轴 9 的延伸部分携带第二活塞 17，该活塞精确地研磨光滑并匹配到气缸 18 上并在气缸 18 中容易地滑动，气缸 18 的端部通常由板和套筒封闭。活塞和气缸都设有分别标记为 19 和 20 的入口和出口。这种布置是熟悉的，是我的发明的原动机的代表，称为“机械振荡器”，用它可以使相当重的系统每分钟振动几千次。

Suppose now that such rapid oscillations are imparted by this or other means to the piston 8. Bearing in mind the proceeding, the operation of the apparatus will be understood at a glance. While moving in the direction of the solid arrow, from 12 to 11, the piston 8 will compress the air or other medium in the compartment 16 and expel it from the same, the devices in the piston and head 11 acting, respectively, as closed and open valves. During the movement of the piston in the opposite direction, from 11 to 12, the medium which has meanwhile filled the chamber 15 will be transferred to compartment 16, egress being prevented by the device in head 12 and that in the piston allowing free passage. These processes will be repeated in very quick succession. If the nipples 4 and 5 are put in communication with independent reservoirs, the oscillations of the piston 8 will result in a compression of the air at 4 and rarefaction of the same at 5. Obviously, the valvular channels being turned the other way, as indicated by dotted lines in the lower part of the figure, the opposite will take place. The devices in the piston have been shown merely by way of suggestion and can be dispensed with. Each of the chambers 15 and 16 being connected to two conduits as illustrated, the vibrations of a solid piston as 8 will have the same effect and the machine will then be a double acting pump or compressor. It is likewise unessential that the medium should be admitted to the cylinder through such devices for in certain instances ports, alternately closed and opened by the piston, may serve the purpose. As a matter of course, this novel method of propelling fluids can be extended to multistage working in which case a number of pistons will be employed, preferably on the same shaft and of different diameters in conformity with well established principles of mechanical design. In this way any desired ratio of compression or degree of rarefaction may be attained.

现在假设这种快速振荡通过这种或其他方式传递给活塞 8。记住这一过程，该装置的操作将一目了然。当活塞 8 沿着实心箭头的方向运动时，从 12 到 11，活塞 8 将隔室 16 中的空气或其他介质压缩并从室 16 中排出，活塞和气缸盖 11 中的装置分别起关闭阀和开启阀的作用。在活塞沿相反方向从 11 到 12 运动的过程中，同时充满腔室 15 的介质将被转移到腔室 16，流出被气缸盖 12 中的装置阻止，而活塞中的装置允许流出自由通过。这些过程将在很短的时间内接连不断地重复。如果喷嘴 4 和 5 与独立的容器连通，活塞 8 的振动将导致空气在 4 处被压缩，在 5 处变稀薄。显然，如果瓣膜通道转向另一个方向，如图下部的虚线所示，将发生相反的情况。活塞中的装置仅通过建议的方式展示，并且可以省去。如图所示，腔室 15 和 16 中的每一个都连接到两个导管，实心活塞（如 8）的振动将具有相同的效果，并且该机器将具有泵或压缩机的双重作用。同样不重要的是，介质应该通过这样的装置进入气缸，因为在某些情况下，由活塞交替关闭和打开的端口可以达到这个目的。当然，这种推进流体的新方法可以扩展到多级工作，在这种情况下，将使用多个活塞，最好地在同一轴上，并且具有不同的直径，符合公认的机械设计原理。以这种方式，可以获得任何预期的压缩比或稀薄度。

Fig. 4 exemplifies a particularly valuable application of the invention to which reference has been made above. The drawing shows in vertical cross section a turbine which may be of any type but is in this instance one invented and described by me and supposed to be familiar to engineers. Suffice it to state that the rotor 21 of the same is composed of flat plates which are set in motion through the adhesive and viscous action of the working fluid, entering the system tangentially at the periphery and leaving it at the center. Such a machine is a thermodynamic transformer of an activity surpassing by far that of any other prime mover, it being demonstrated in practice that each single disk of the rotor is capable of performing as much work as a whole bucketwheel. Besides, a number of other advantages, equally important, make it especially adapted for operation as an internal combustion motor. This may be done in many ways, but the simplest and most direct plan of which I am aware is the one illustrated here. Referring again to the drawing, the upper part of the turbine casing 22 has bolted to it a separate casting 23, the central cavity 24 of which forms the combustion chamber. To prevent injury through excessive heating a jacket 25 may be used, or else water injected, and when these means are objectionable recourse may be had to air cooling, this all the more readily as very high temperatures are practicable. The top of casting 23 is closed by a plate 26 with a sparking or hot wire plug 27 and in its sides are screwed two valvular conduits communicating with the central chamber 24. One of these is, normally, open to the atmosphere while the other connects to a source of fuel supply as a gas main 28. The bottom of the combustion chamber terminates in a suitable nozzle 29 which consists of separate piece of heat resisting material. To regulate the influx of the explosion constituents and secure the proper mixture the air and gas conduits are equipped, respectively, with valves 30 and 31. The exhaust openings 32 of the rotor should be in communication with a ventilator, preferably carried on the same shaft and of any suitable construction. Its use, however, while advantageous, is not indispensable the suction produced by the turbine rotor itself being, in some cases at least, sufficient to insure proper working. This detail is omitted from the drawing as unessential to the understanding.

图 4 举例说明了本发明的一个特别有价值的应用，上面已经作了参考。该图展示了涡轮机的垂直截面，该涡轮机可以是任何类型，但是在这种情况下，该涡轮机是由我发明和描述的，并且被认为是工程师所熟悉的。只要说明转子 21 由平板组成就足够了，平板通过工作流体的黏滞性和黏附性而运动，流体在外围切向进入系统，在中心离开系统。这种机器是一个热力学转换器，其活动远远超过任何其他原动机，它在实践中证明，转子的每个单独的圆盘能

够完成一个完整的庠斗轮的工作。此外，许多其他同样重要的优点，使它特别适合作为内燃机来运行。这可以通过许多方式来实现，但我所知道的最简单、最直接的方案是这里所展示的方案。再次参照附图，涡轮机壳体 22 的上部用螺栓固定了一个独立的铸件 23，铸件的中心空腔 24 形成了燃烧室。为了防止由于过度加热造成的损害，可以使用夹套 25，或者注射水，并且当这些措施不合适时，可以求助于空气冷却，由于非常高的温度是可行的，所以这样做更加容易。铸件 23 的顶部由带有火花塞或热丝塞 27 的板 26 封闭，并且在其侧面拧有两个与中心腔室 24 连通的瓣膜导管。其中一个通常通向大气，而另一个连接到作为气体总管 28 的燃料供应源。燃烧室的底部终止于一个合适的喷嘴 29，该喷嘴由单独的耐热材料制成。为了调节爆炸成分的流入并确保适当的混合，空气和气体导管分别装有阀 30 和 31。转子的排气口 32 应该与一个通风设备连通，该通风设备优选地被承载在同一轴上并且具有任何合适的结构。然而，它的使用虽然是有优势的，但并不是必不可少的，至少在某些情况下，涡轮转子本身产生的吸力足以确保正常工作。这个细节对于理解是不重要的，所以从图中省略了。

But a few words will be needed to make clear the mode of operation. The air valve 30 being open and sparking established across terminals 27, the gas is turned on slowly until the mixture in the chamber 24 reaches the critical state and is ignited. Both the conduits behaving, with respect to efflux, as closed valves, the products of combustion rush out through the nozzle 29 acquiring still greater velocity by expansion and, imparting their momentum to the rotor 21, start it from rest. Upon the subsidence of the explosion the pressure in the chamber sinks below the atmosphere owing to the pumping action of the rotor or ventilator and new air and gas is permitted to enter, cleaning the cavity and channels and making up a fresh mixture which is detonated as before, and so on, the successive impulses of the working fluid producing an almost continuous rotary effort. After a short lapse of time the chamber becomes heated to such a degree that the ignition device may be shut off without disturbing the established regime. This manner of starting the turbine involves the employment of an unduly large combustion chamber which is not commendable from the economic point of view, for not only does it entail increased heat losses but the explosions cannot be made to follow one another with such rapidity as would be desirable to insure the best valvular action. When the chamber is small an auxiliary means for starting, as compressed air, may be resorted to and a very quick succession of explosions can then be obtained. The frequency will be the greater the stronger the suction, and may, under certain conditions, reach hundreds and even thousands per second. It scarcely need be stated that instead of one several explosion chambers may be used for cooling purposes and also to increase the number of active pulses and the output of the machine.

但是需要说几句话来说明运行模式。空气阀 30 打开并且两个端子 27 之间产生火花，气体被缓慢打开，直到室 24 中的混合物达到临界状态并被点燃。就流出量而言，两个导管都表现为关闭的阀，燃烧产物通过喷嘴 29 冲出，通过膨胀获得更大的速度，并将它们的动量传递给转子 21，使其从静止状态开始转动。当爆炸平息时，由于转子或通风设备的泵送作用，燃烧室中的压力下降到大气压以下，新的空气和气体被允许进入，清洁空腔和通道，并形成新鲜的混合物，该混合物如前所述被引爆，等等，工作流体的连续脉冲产生几乎连续的旋转作用力。经过一小段时间后，燃烧室被加热到这样的程度，即点火装置可以被关闭而不会干扰已建立的管理机制。这种启动涡轮机的方式涉及使用一个过大的燃烧室，从经济角度来看这是不可取的，因为这不仅增加了热损失，而且爆炸不能以确保最佳瓣膜作用所需的速度相继发生。当燃烧室很小时，可以采用用于启动的辅助手段，如压缩空气，然后可以获得非常快速的连续爆炸。吸力越强，频率就越大，在一定条件下，可以达到每秒数百甚至数千次。几

乎不需要说明的是，不是使用一个爆炸室，几个爆炸室可以用于冷却的目的，并且还可以增加有效脉冲的数量和机器的输出。

Apparatus as illustrated in Fig. 4 presents the advantages of extreme simplicity, cheapness and reliability, there being no compressor, buckets or troublesome valve mechanism. It also permits, with the addition of certain well-known accessories, the use of any kind of fuel and thus meets the pressing necessity of a self-contained, powerful, light and compact internal combustion motor for general work. When the attainment of the highest efficiency is the chief object, as in machines of large size, the explosive constituents will be supplied under high pressure and provision made for maintaining a vacuum at the exhaust. Such arrangements are quite familiar and lend themselves so easily to this improvement that an enlargement on this subject is deemed unnecessary.

图 4 所示的装置具有极其简单、廉价和可靠的优点，没有压缩机、斗部或麻烦的阀门结构。它还允许添加某些众所周知的附件，使用任何种类的燃料，从而满足了一般工作所需的独立、强大、轻便和紧凑的内燃机的迫切需要。当获得最高效率是主要目标时，如在大型机器中，爆炸成分将在高压下供应，并采取措施在排气时维持真空。这种安排是非常熟悉的，很容易使它们自己有所改进，因此认为没有必要扩大这个主题。

The foregoing description will readily suggest to experts modifications both as regards construction and application of the device and I do not wish to limit myself in these respects. The broad underlying idea of the invention is to permit the free passage of a fluid through a channel in the direction of the flow and to prevent its return through friction and mass resistance, thus enabling the performance of valve functions without any moving parts and thereby extending the scope and usefulness of an immense variety of mechanical appliances.

前面的描述将容易地向专家建议关于装置的结构和应用的修改，并且我不希望在这些方面限制自己。本发明的主要基本思想是允许流体沿流动方向自由通过通道，并通过摩擦和物质阻力防止其回流，从而能够在没有任何移动部件的情况下执行阀门功能，并由此扩展了各种机械设备的范围和用途。

I do not claim the methods of and apparatus for the propulsion of fluids and thermodynamic transformation of energy herein disclosed, as these will be made subjects of separate applications.

我没有主张在此公开的用于流体推进和能量热力学转换的方法和装置，因为这些将成为单独申请的主题。

I am aware that asymmetrical conduits have been constructed and their use proposed in connection with engines, but these have no similarity either in their construction or manner of employment with my valvular conduit. They were incapable of acting as valves proper, for the fluid was merely arrested in pockets and deflected through 90° , this result having at best only 25% of the efficiency attained in the construction herein described. In the conduit I have designed the fluid, as stated above, is deflected in each cycle through 360° , and a co-efficient approximating 200 can be obtained so that the device acts as a slightly leaking valve, and for that reason the term "valvular" has been given to it in contrast to asymmetrical conduits, as heretofore proposed, which were not valvular in action, but merely asymmetrical as to resistance.

我意识到不对称导管已经被制造，并且它们的使用被提出与发动机相关联，但是这些在它们的构造或使用方式上与我的瓣膜导管没有相似之处。它们不能完全起到阀门的作用，因为流体仅仅滞留在凹穴中并偏转 90° ，这种结果最多只有从这里描述的结构中获得的效率的 25%。在我设计的导管中，如上所述，流体在每个循环中偏转 360° ，并且可以获得大约 200 的系数，使得该装置充当轻微的泄漏阀，并且由于这个原因，术语“瓣膜的”已经被赋予到该装置，与不对称的导管相反，如前所述，不对称的导管在作用中不是瓣膜的，而仅仅是阻力不对称。

Furthermore, the conduits heretofore constructed were intended to be used in connection with slowly reciprocating machines, in which case enormous conduit-length would be necessary, all this rendering them devoid of practical value. By the use of an effective valvular conduit, as herein described, and the employment of pulses of very high frequency, I am able to condense my apparatus and secure such perfect action as to dispense successfully with valves in numerous forms of reciprocating and rotary engines.

此外，迄今为止构造的导管旨在与缓慢往复运动的机器结合使用，在这种情况下，巨大的导管长度将是必要的，所有这些使得它们缺乏实用价值。通过使用有效的瓣膜导管，如本文所述，以及采用非常高频率的脉冲，我能够精简我的装置并确保这样的完美动作，从而成功地免除了多种形式的往复式和旋转式发动机中的阀门。

The high efficiency of the device, irrespective of the character of the pulses, is due to two causes: first, rapid reversal of direction of flow and, second, great relative velocity of the colliding fluid columns. As will be readily seen each bucket causes a deviation through an angle of 180° , and another change of 180° occurs in each of the spaces between two adjacent buckets. That is to say, from the time the fluid enters or leaves one of the recesses to its passage into, or exit from, the one following a complete cycle, or deflection through 360° , is effected. Observe now that the velocity is but slightly reduced in the reversal so that the incoming and deflected fluid columns meet with a relative speed, twice that of the flow, and the energy of their impact is four times greater than with a deflection of only 90° , as might be obtained with pockets such as have been employed in asymmetrical conduits for various purposes. The fact is, however, that in these such deflection is not secured, the pockets remaining filled with comparatively quiescent fluid and the latter following a winding path of least resistance between the obstacles interposed. In such conduits the action cannot be characterized as “valvular” because some of the fluid can pass almost unimpeded in a direction opposite to the normal flow. In my construction, as above indicated, the resistance in the reverse may be 200 times that in the normal direction. Owing to this a comparatively very small number of buckets or elements is required for checking the fluid. To give a concrete idea, suppose that the leak from the first element is represented by the fraction $1/x$, then after the n th bucket is traversed, only a quantity $(1/x)^n$ will escape and it is evident that X need not be a large number to secure a nearly perfect valvular action.

不管脉冲的特征如何，该装置的高效率是由于两个原因：第一，流动方向的快速逆转，第二，碰撞流体柱的相对速度大。很容易看出，每个斗部导致 180° 的偏转，并且在两个相邻斗部之间的每个空间中发生另一个 180° 的变化。也就是说，从流体进入或离开一个壁凹的时间到它进入或离开另一个壁凹的时间，完成一个完整的循环，或偏转 360° 。现在观察到，速度在反向时只是稍微减小，因此进入的液柱和被偏转的液柱以两倍流动速度的相对速度相遇，并且它们的碰撞能量是仅偏转 90° 时的四倍，这可以通过例如用于各种目的的不对称

导管中的凹穴获得。然而，事实是，在这些情况下，这种偏转是不可靠的，凹穴保持充满相对静止的流体，并且后者沿着障碍物之间的最小阻力的弯曲路径行进。在这种导管中，这种作用不能被描述为“瓣膜性的”，因为一些流体可以在与正常流动相反的方向上几乎不受阻碍地通过。如上所述，在我的结构中，反向阻力可能是正向阻力的 200 倍。由于这个原因，需要相对非常少的斗部或组件来阻挡流体。为了给出一个具体的想法，假设来自第一个组件的泄漏由分数 $1/x$ 表示，那么在经历了第 n 个斗部之后，只有数量 $(1/x)^n$ 将逃逸，并且很明显， X 不需要是一个大的数字来确保几乎完美的瓣膜作用。

What I claim is:

我主张的是：

1. A valvular conduit having interior walls of such conformation as to permit the free passage of fluid through it in the direction of flow but to subject it to rapid reversals of direction when impelled in the opposite sense and thereby to prevent its return by friction and mass resistance.

1、一种瓣膜导管，其内壁构造允许流体沿流动方向自由通过，但当沿相反方向推动时会使流体方向迅速逆转，从而通过摩擦和物质阻力防止流体回流。

2. A valvular conduit composed of a closed passageway having recesses in its walls so formed as to permit a fluid to pass freely through it in the direction of flow, but to subject it to rapid reversals of direction when impelled in an opposite sense and thereby interpose friction and mass resistance to the return passage of the same.

2、一种瓣膜导管，由其壁中具有壁凹的封闭通道组成，该通道的形状允许流体沿流动方向自由通过，但当沿相反方向推动时，会使流体方向迅速逆转，从而对导管的回流通道产生摩擦和物质阻力。

3. A valvular conduit composed of a tube or passageway with rigid interior walls formed with a series of recesses or pockets with surfaces that reverse a fluid tending to flow in one direction therein and thereby check or prevent flow of the fluid in that direction.

3、一种瓣膜导管，由具有刚性内壁的管或通道组成，这些管或通道形成有一系列壁凹或凹穴，这些壁凹或凹穴的表面使倾向于在其中一个方向上流动的流体反向，从而阻止或防止流体在该方向流动。

4. A valvular conduit with rigid interior walls of such character as to offer substantially no obstacle to the passage through it of fluid impulses in one direction, but to subject the fluid to rapid reversals of direction and thereby oppose and check impulses in the opposite sense.

4、一种具有刚性内壁的瓣膜导管，其特点是基本上不会阻碍一个方向的流体脉冲通过它，但会使流体快速反转方向，从而阻止和抑制相反方向的脉冲。

5. A valvular conduit with rigid interior walls formed to permit fluid impulses under pressure to pass freely through it in one direction, but to subject them to rapid reversals of direction through 360° and

thereby check their progress when impelled in the opposite sense.

5、一种具有刚性内壁的瓣膜导管，允许压力下的流体脉冲在一个方向上自由通过，但使其通过 360° 快速反转，从而当沿相反方向推动流体时，阻止流体前进。

6. A valvular conduit with rigid interior walls which permit fluid impulses to flow through it freely in one direction, formed at a plurality of points to reverse such fluid impulses when impelled in the opposite direction and check their flow.

6、一种具有刚性内壁的瓣膜导管，允许流体脉冲沿一个方向自由流过它，当沿相反方向推动流体时，这种导管会在多个点逆转这种流体脉冲并阻止其流量。

7. A valvular conduit with rigid interior walls having pockets or recesses, and transversely inclined intermediate baffles to permit the free passage of fluid impulses in one direction but to deflect and check them when impelled in the opposite direction.

7、一种具有刚性内壁的瓣膜导管，该内壁具有凹穴或壁凹，该导管还有横向倾斜的中间挡板，以允许流体脉冲在一个方向上自由通过，但当在相反方向推动流体会偏转并阻止它们。

In testimony whereof I affix my signature.

我签名为证。

NIKOLA TESLA.

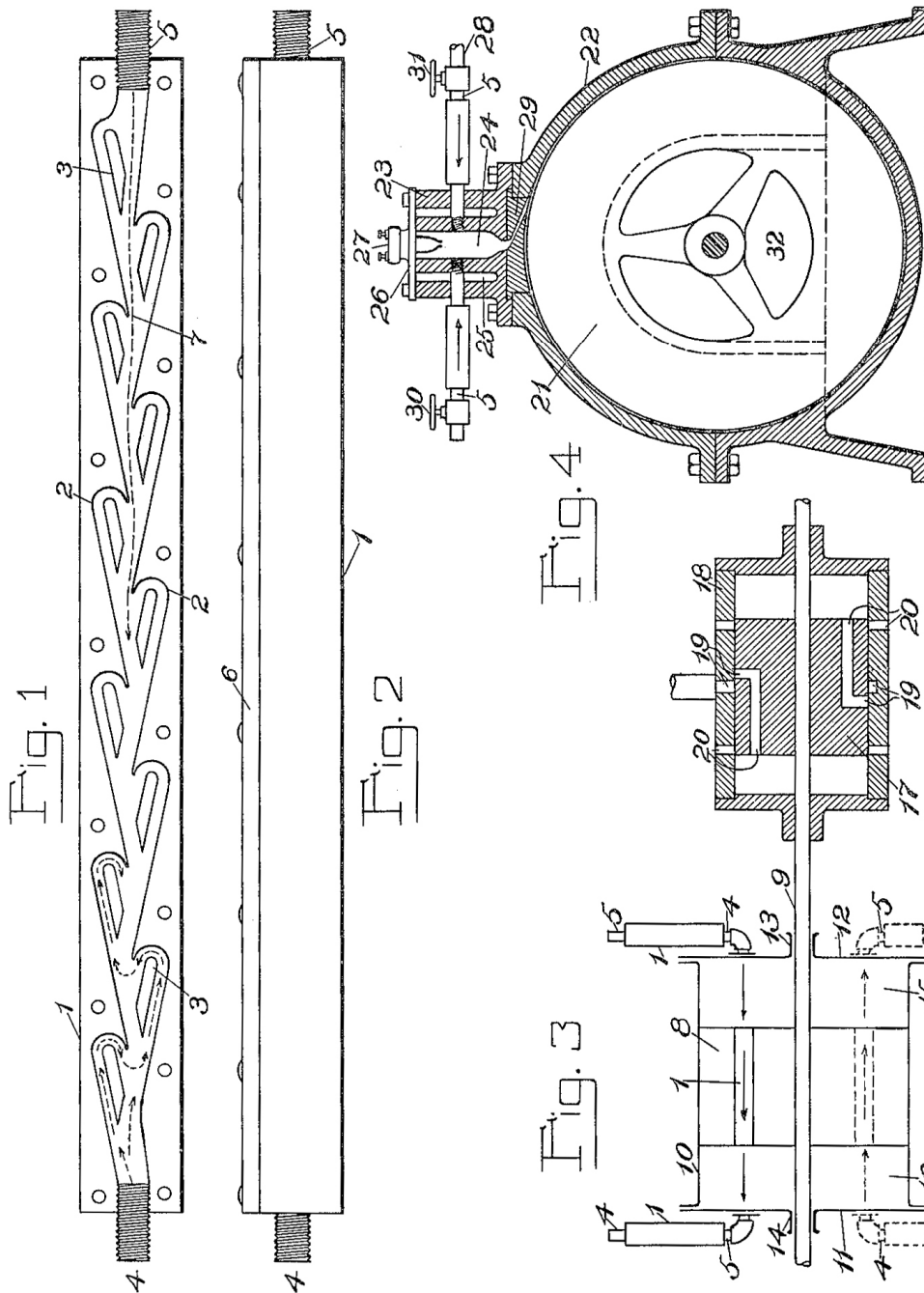
尼古拉·特斯拉

N. TESLA.
VALVULAR CONDUIT.

APPLICATION FILED FEB. 21, 1916. RENEWED JULY 8, 1919.

1,329,559.

Patented Feb. 3, 1920.



INVENTOR

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BY

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FLOW-METER.

流量计

NIKOLA TESLA, OF NEW YORK, N. Y., ASSIGNOR TO WALTHAM WATCH COMPANY,
OF WALTHAM, MASSACHUSETTS, A CORPORATION OF MASSACHUSETTS.

纽约州纽约市的尼古拉·特斯拉，将专利权转让给马萨诸塞州沃尔瑟姆市的
沃尔瑟姆钟表公司，它是马萨诸塞州的一家公司。

1,365,547. Specification of Letters Patent. Patented Jan. 11, 1921.

Application filed December 18, 1916. Serial No. 137,688.

专利证书说明书第 1,365,547 号。在 1921 年 1 月 11 日被授予专利。

申请于 1916 年 12 月 18 日。序列号为 137,688。

To all whom it may concern:

致所有相关人士：

Be it known that I, NIKOLA TESLA, a citizen of the United States, residing at New York, in the county and State of New York, have invented certain new and useful Improvements in Flow-Meters, of which the following is a full, clear, and exact description.

众所周知，我、尼古拉·特斯拉、一位美国公民，居住在纽约州纽约郡纽约市，在流量计方面已经发明了某些新的和有用的改进，以下是该发明一个完整的、清晰的和准确的描述。

My invention relates to meters for measurement of velocity or quantity of fluid flow. Its chief object is to provide a novel structure, simple, inexpensive and efficient, directly applicable to a conduit through which the fluid flows, and arranged to give instantaneous readings in terms of velocity, or quantity.

我的发明涉及用于测量流体流速或流量的仪表。其主要目的是提供一种新颖的结构，简单、便宜且有效，可直接应用于流体流经的导管，并设置成根据速度给出瞬时读数或流量。

In the drawings I have shown a single embodiment of my invention in desirable form, and therein—Figure 1 is a central, vertical section showing the device in use; Fig. 2 is a plan detail of the indicating instrument with parts in section; Fig. 3 is a horizontal section on line 3—3 of Fig. 1, and Fig. 4 is an enlarged section on line 4—4 of Fig. 1.

在附图中，我已经以预期的形式展示了我的发明的单个实施例，并且其中—图 1 是展示使用中的装置的中央垂直截面图；图 2 是具有部分截面的指示仪器的平面详细图；图 3 是沿图 1 中的线 3—3 的水平截面图，以及图 4 是图 1 中的线 4—4 的截面放大图。

Assuming that the flow of liquid 10 through a main 11 is to be measured as in gallons per hour, or feet per second, the main is tapped as at 12 and into the threaded orifice is screwed the body-casting of the

flow-meter 13. This casting has a threaded waist 14, centrally apertured to receive the bearing bushing 15, the upper portion of the casting being formed as a shell 16 for incasing the indicating mechanism, and its lower portion prolonged as a tube 17, terminating in a head 18 to receive the flow-driven element. The latter, I prefer, shall be a turbine of the type commonly identified by my name. Illustrating simply its essential elements, the rotor, 19, is made up of centrally apertured parallel disks 20, closely spaced and mounted on a shaft, 21, extending through a shell 22 confined within the head 18 above the plug 23 that closes the bottom of the head and carries an adjustable step-bearing screw 24. Inlet nozzles 25, in the wall of head 18, direct the liquid to the disks tangentially to set the latter in rotation and the water finds escape through the outlet passages 26 of the shell 22 and ports 27 of the head 18. Preferably the length of tube 17 should be such as to dispose the turbine rotor approximately at the center of the main, and of course the turbine will rotate at a rate linearly proportional to the velocity of the fluid at that point, according to a practically-determined constant.

假设通过主管道 11 的液体 10 的流量以加仑/小时或英尺/秒来测量，主管道在 12 处被攻出螺纹，并且流量计 13 的主体铸件被拧入螺纹孔中。该铸件具有带螺纹的腰部 14，其中心有孔以容纳轴承衬套 15，铸件的上部形成为用于容纳指示机械结构的壳体 16，其下部延伸为管 17，终止于头部 18，该头部用来容纳流体驱动部件。我更喜欢这种驱动部件通常是由我的名字来识别其类型的一种涡轮机。简单地展示出其基本组件，转子 19 由中心有孔的平行圆盘 20 组成，平行圆盘 20 紧密间隔并安装在轴 21 上，轴 21 延伸穿过外壳 22，外壳 22 被限制在头部 18 内，在塞子 23 上方，塞子 23 封闭头部的底部并带有可调节的立式止推轴承螺钉 24。头部 18 的壁中的入口喷嘴 25 将液体切向引导至圆盘，以使圆盘旋转，并且水流通过壳体 22 的出口通道 26 和头部 18 的端口 27 逸出。管 17 的长度应该最好使得涡轮转子大约位于主管道的中心，当然，根据实际确定的常数，涡轮将以与流体在该点的速度成线性比例的速率旋转。

Turbine shaft 21 connects with shaft 30 of the indicator, that preferably is of minimal diameter for the work to be done and that passes through the long bushing 15 for direct connection with the indicator 31. The primary element, 32, of this indicator, directly mounted on said shaft 30, preferably comprises a cup having multiple vertical walls 33 in concentric arrangement, these being interleaved with inverted cup walls 34 of a secondary element 35, that is pivoted and torsionally restrained and that bears a movable element of the reading scale. Specifically, the secondary element may have its inverted cup walls made of very thin aluminum mounted on arm 36, affixed to the spindle 37 that runs in jewel bearings carried by a yoke 38, supported on a bridge piece 39 spanning the casing 16. A coiled spring 40, at one end fast to the spindle 37 and its other end adjustably secured in split stud 41, on bracket 38, resists displacement of the secondary element which carries on its top a reading scale 43, graduated in terms of gallons per hour, feet per minute, or other units of measurement. This dial moves below the stationary pointer 44 that is visible through the sight-glass 45, carried by the cover cap 46 and tightly sealed. By constructing the indicator in accordance with principles fully explained in my Patent No. 1,209,359 the primary element, acting through the viscous or adhesive properties of air or other fluid medium filling the casing, is caused to displace the scale-bearing member against the tension of its spring substantially in linear proportion to the speed of rotation of the primary element, and by observing the conditions requisite to make the torque bear a rigorously linear proportion to the speed, and making the spring to permit deflections proportionate directly to the turning effort, the scale may be graduated uniformly without the employment of any compensating mechanism to this end.

涡轮轴 21 与指示器的轴 30 连接，轴 30 最好具有用于待完成工作的最小直径，并且穿过长衬套 15 来与指示器 31 直接连接。该指示器的初级组件 32 直接安装在所述轴 30 上，最好构成具有同心布置的多个垂直壁 33 的杯，这些垂直壁与次要组件 35 的倒置杯壁 34 交错，次要组件 35 被枢转和被扭转限制，并且承载读数标尺的可移动组件。具体地说，次级组件可以具有由非常薄的铝制成的倒置的杯状壁，该杯状壁被安装在臂 36 上，臂 36 被固定到心轴 37 上，心轴 37 在由轭 38 承载的宝石轴承中运行，轭 38 被支撑在横跨壳体 16 的桥接件 39 上。螺旋弹簧 40 的一端固定在心轴 37 上，另一端可调整地被固定在支架 38 上的双头嵌钉 41 中，该螺旋弹簧阻碍次要组件的位移，该次要组件在其顶部带有读数刻度 43，该刻度以加仑/小时、英尺/分钟或其它测量单位来表示。该刻度盘在静态指针 44 的下方移动，该指针通过观察玻璃 45 可见，该观察玻璃由罩盖 46 承载并紧密密封。通过根据本人的专利第 1,209,359 号中充分说明的原理来构建指示器，通过被填充到壳体内部的空气或其它流体介质的黏附性或黏滞性来起作用的初级组件使得刻度支承部件克服其弹簧的张力，与初级组件的旋转速度基本成线性比例地移动，并且通过观察使扭矩与速度成严格线性比例的必要条件，并使弹簧允许偏转与旋转力成正比，标尺可以均匀地刻度，而不需要为此目的使用任何补偿机制。

The pressure or density of the gaseous fluid medium in the casing 60 should not be subject to change under varying conditions of pressure within the main, or the readings might be seriously inaccurate; nor, obviously, should escape of the liquid from the main into the indicator casing be permitted. To seal the running bearing of shaft 30 adequately to withstand very considerable pressures, I make what I term a “mercury-lock” by the following provision: the shaft 30 is made of fine steel of great and uniform density and the bushing 15 is preferably of hard copper, these having diameters leaving a clearance of only a few thousandths of an inch,—much too small for the capillary admission of mercury. These surfaces are treated for amalgamation with mercury. The bearing-portion of the shaft 30 is thinly copper plated, and then both bearing surfaces are coated, in a quickening solution, with mercury, after which the mercury-filmed parts are assembled. In this way, as sought graphically and exaggeratedly to be represented in Fig. 4, the mercury body 50 is introduced into the very narrow clearance, and although it is a unitary seal in its resistance to the passage of air or water, it may practically be regarded as forming two mirror-surfaced films between the bushing 15 and the copper plating 51 of shaft 30. I have found such a mercury lock makes a very effective and enduring seal while permitting adequately free rotation of the shaft.

外壳 60 中气态流体介质的压力或密度不应在主管道内压力变化的条件下发生变化，否则读数可能会严重不准确；显然，也不应该允许液体从主管道内泄漏到指示器的外壳中。为了充分密封轴 30 的运转轴承以承受非常大的压力，我通过以下措施制造了我称之为“水银锁”的装置：轴 30 由密度大且匀质的精钢制成，衬套 15 首选硬铜制成，这些组件的直径仅留下千分之几英寸的间隙——对于水银的毛细管的进入来说太小了。这些表面经过处理用于与水银齐化（汞齐化）。轴 30 的轴承部分镀了薄铜，然后在一种使其活泼的溶液中用水银涂覆两个轴承表面，之后组装镀了水银膜的部件。以这种方式，如在图 4 中用图形和夸张地表示的那样，水银体 50 被引入到非常窄的间隙中，尽管它在阻止空气或水通过方面是一个整体密封，但实际上可以认为它在衬套 15 和轴 30 的镀铜层 51 之间形成了两个镜面薄膜。我发现这种水银锁在允许轴充分自由旋转的同时，可以形成非常有效和持久的密封。

The combination of turbine rotor and air drag indicating mechanism as above described is especially advantageous in that the small turbine, developing a high shaft speed under even rather slow fluid flow,

insures that the speeds of the primary element will be ample to result in high torque, so that the indicator may be of relatively rugged construction. Furthermore, the practical insensibility of the air drag instrument to temperature changes, without special compensating mechanism, makes very simple construction available for many and variant uses. And since linear relationships exist between the rate of liquid flow, turbine-rotation and indicator-displacement, accurate marking of the scale in uniform graduations depends only upon the establishment of certain easily-ascertainable constants for any given conditions.

如上所述的涡轮转子和空气拖动指示机械装置的组合是特别有优势的,因为小涡轮在甚至相当慢的流体流动下也能产生高的轴速度,确保初级组件的速度将足以产生高扭矩,以至于指示器要具有相对坚固的结构。此外,在没有特殊补偿机制的情况下,空气拖动仪器对温度变化的实际不敏感性使得非常简单的结构可用于许多不同的用途。并且由于液体流速、涡轮转速和指示器位移之间存在线性关系,所以以均匀分度准确地标记刻度仅取决于为任何给定条件建立某些容易确定的常数。

What I claim is:

我主张的是:

1. A flow-meter comprising a body having a pipe engaging portion, a lower head of smaller diameter and an upper casing, a vertical shaft extending through said body, a disk-turbine in said head directly connected with said shaft, said head having inlet and outlet openings to the turbine disks, and indicating means comprising a rotatable primary element directly connected with said vertical shaft and a torsionally-restrained secondary element displaceable by the first and equipped to show its displacement in desired terms.

1、一种流量计,包括一个具有管道接合部分的主体;较小直径的下头部和上壳体;延伸穿过所述主体的垂直轴;在所述头部中与所述轴直接连接的盘式涡轮,所述头部具有通向涡轮盘的入口和出口;以及指示装置,该指示装置包括与所述垂直轴直接连接的可旋转初级组件和由第一组件施加移位并被装备成以预期的方式显示其移位的受扭转约束的次级组件。

2. In a device of the character described, the combination of a body fitting having an intermediate part for pipe engagement, a lower head, and an upper shell, a shaft passing vertically from said shell to said head, a pressure-resisting seal for said shaft adjacent said pipe engaging portion of the body, an indicator in said shell comprising a rotatable primary member having a vertical axis and directly connected with the upper end of said shaft, a torsionally-restrained secondary element displaceable by the first, said secondary element associated with a scale for showing its deflections in desired terms, and a horizontal disk-turbine rotor in said head, said rotor directly connected with the bottom of said shaft, said head having inlet and outlet openings to the rotor disk.

2、在所述特征的一个装置中,存在一个组合,包括一个主体配件,它具有用于管接的中间部件、下头部和上壳体;一个轴,从所述壳体垂直穿过,到达所述头部;一个耐压密封件,用于邻近所述管的所述轴主体的接合部分;在所述壳体中的一个指示器,它包括具有垂直轴并直接与所述轴的上端连接的可旋转主构件;由第一组件施加移位的被扭转约束的次级组件,所述次级组件与用于以预期的方式显示该组件偏转的标尺相关联;以及在所述头部中的

水平盘式涡轮转子，所述转子与所述轴的底部直接连接，所述头部具有通向转子盘的入口和出口。

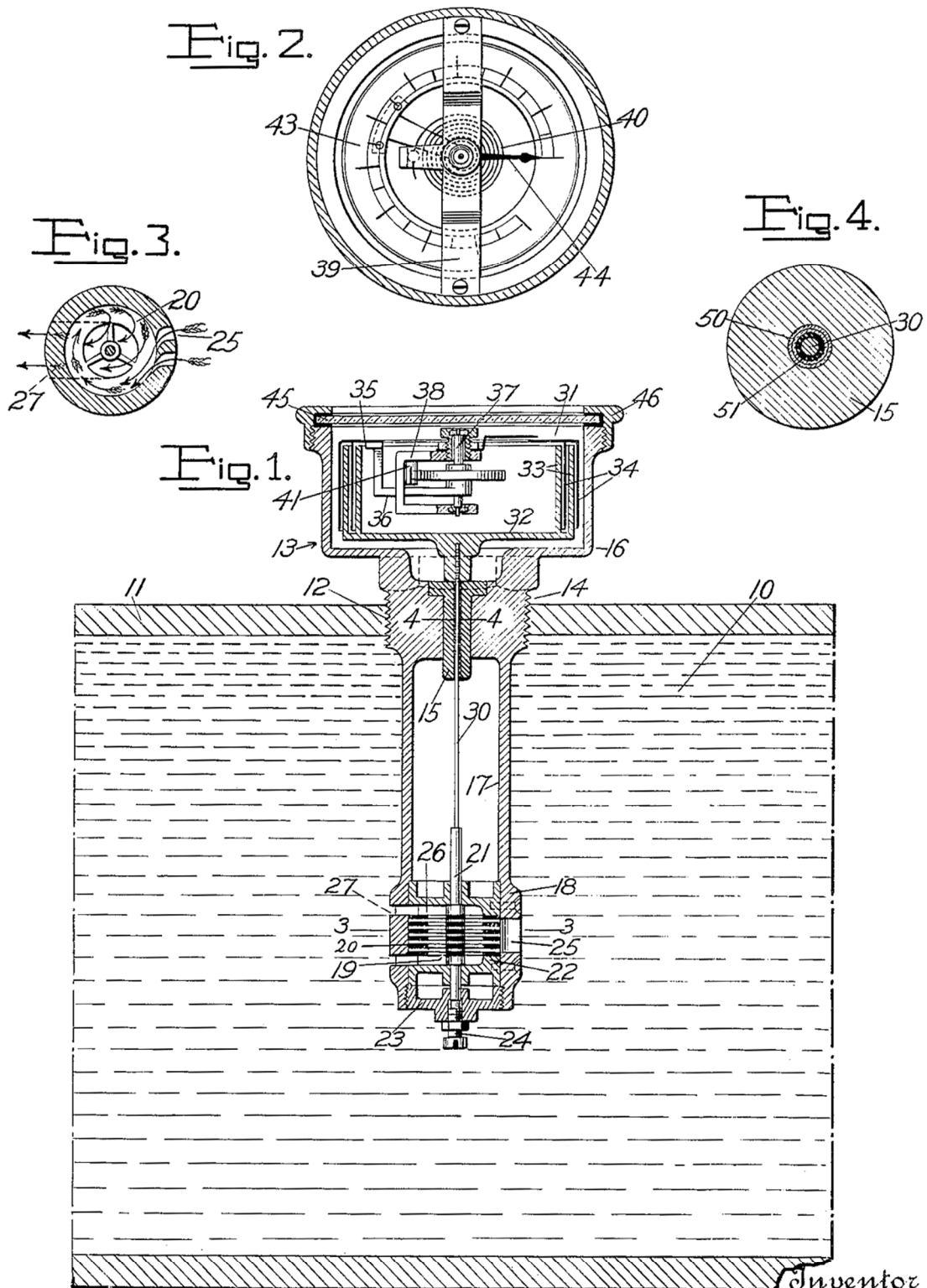
In testimony whereof I affix my signature.
我签名为证。

NIKOLA TESLA.
尼古拉·特斯拉

N. TESLA.
FLOW METER.
APPLICATION FILED DEC. 18, 1916.

1,365,547.

Patented Jan. 11, 1921.



Inventor
Nikola Tesla
By his Attorneys
Forée Bain & May

FREQUENCY METER.

频率计

NIKOLA TESLA, OF NEW YORK, N. Y., ASSIGNOR TO WALTHAM WATCH COMPANY,
OF WALTHAM, MASSACHUSETTS, A CORPORATION OF MASSACHUSETTS.

纽约州纽约市的尼古拉·特斯拉，将专利权转让给马萨诸塞州沃尔瑟姆市的
沃尔瑟姆钟表公司，它是位于马萨诸塞州的一家公司。

1,402,025. Specification of Letters Patent. Patented Jan. 3, 1922.

Application filed December 18, 1916. Serial No. 137,689.

专利证书说明书第 1,402,025 号。在 1922 年 1 月 3 日被授予专利。

申请于 1916 年 12 月 18 日。序列号为 137,689。

To all whom it may concern:

致所有相关人士:

Be it known that I, NIKOLA TESLA, a citizen of the United States, residing at New York, in the county and State of New York, have invented certain new and useful Improvements in Frequency Meters, of which the following is a full, clear, and exact description.

众所周知，我、尼古拉·特斯拉，一位美国公民，居住在纽约州纽约郡纽约市，在频率计方面已经发明了某些新的和有用的改进，以下是该发明一个完整的、清晰的和准确的描述。

In many instances in practice it is very desirable and important to ascertain the frequency of periodic currents or electric oscillations and therefrom the speed of rotation or reciprocation of the generating or controlling apparatus.

在实践中的许多情况下，确定周期性电流或电振荡的频率，并由此确定发电或控制装置的旋转速度或往复运动的速度是非常需要和重要的。

The devices commonly used at present for this purpose and designated “frequency meters” generally consist of reeds or bars tuned to respond to impulses of definite periods, or a direct current dynamo coupled to the alternating generator or frequency controller and connected with an instrument, of voltmeter construction, graduated to indicate the instantaneous frequency of the current. Both of these forms are objectionable from many points of view, being subject to various limitations of practical availability and to disturbing influences, all so well known to experts as to dispense with the necessity of enlarging upon them on this occasion.

目前通常用于此目的的装置和指定的“频率计”通常由簧片或棒组成，这些簧片或棒被调谐以响应确定周期的脉冲，或者由耦合到交流发电机或频率控制器并与具有电压表结构的仪器连接的一个直流发电机组成，该仪器被刻度来指示电流的瞬时频率。从许多观点来看，这两

种形式都是令人反感的，受到实际可用性的各种限制和干扰的影响，所有这些对专家来说都是众所周知的，因此在这种情况下无需详述。

My invention has for its object to provide a frequency meter of great accuracy, structural simplicity, wide range of use, and low cost, all adequate to meet the pressing demand for a commercial and scientifically satisfactory instrument of improved form.

我的发明的目的是提供一种非常精确、结构简单、使用范围广、成本低廉的频率计，所有这些都足以满足对改进的能在商用和科学研究中令人满意的一种仪器的迫切需求。

In the drawings, wherein I have illustrated a single embodiment of my invention for purposes of disclosure,—

在附图中，为了公开的目的，我已经展示了我的发明的单个实施例—

Fig. 1 is a central vertical section through the frequency meter, with diagrammatic extension to indicate an available manner of connecting it to a two-phase generator; Fig. 2 is an end view; Fig. 3 is a side elevation with the cover in section, and Fig. 4 is a side elevation of the instrument from its reading side.

图 1 是穿过频率计的中央垂直截面图，带有示意性的扩展以指示将其连接到两相发电机的可用方式；图 2 是端视图；图 3 是带有盖子的侧视图，图 4 是仪器的读数一侧的侧视图。

It will be understood that the specific construction of instruments embodying my invention may be modified in many ways according to the demands of the electrical or mechanical environment in which it is to be used, and while I shall describe in detail a specific construction, illustrated in the drawing, it is without intent to limit my invention in its broader aspects to matters of detail.

应当理解，体现本发明的仪器的具体结构可以根据其使用的电气环境或机械环境的要求以多种方式进行修改，并且尽管我将详细描述附图中所示的特定结构，但这并不意味着将本发明的更广泛的方面限制在细节问题上。

5 represents diagrammatically a two-phase generator, typifying the machine controlling the frequency to be measured, and having suitable connection by wires 6 with the synchronous-motor element of the frequency meter, indicated as a whole by 7. The motor, 8, will of course have field poles and armature bars appropriate to the character of the current supplied from the generator 5, the motor being of the split-phase, two-phase, or other type, as needed. A frame 10, having lugs 11, or other means of support, provides a cup-formed shell 12 with a top wall 13 furnished with a central bearing tube 14 and with suitable supporting means, as 15, for the stationary field structure 16. A cap 17, screw threaded at 18, and suitably packed, hermetically seals one side of the motor casing into which the connecting wires are led through any suitable sealing and insulating bushings 19.

5 示意性地表示一个两相发电机，代表控制着待测频率的机器，并通过导线 6 与频率计的同步电动机组件适当连接，频率计作为一个整体用 7 表示。电动机 8 当然将具有适合于由发电机 5 提供的电流的特性的场磁极和电枢棒，电动机根据需要可以是分相式、两相式或其他类型。具有线耳 11 或其它支撑装置的框架 10 提供了杯形壳体 12，该壳体具有顶壁 13，该顶

壁装备有中心轴承管 14 和用于静态磁场构件 16 的适合的支撑装置 15。在 18 处有螺纹并被适当包装的帽 17 气密地密封电动机外壳的一侧，连接线通过任何适当的密封和绝缘套管 19 被引入到该电动机外壳中。

For accuracy and promptness of response to frequency-variations, the armature structure 21, as a whole, with its attachments should be of very light weight and so equipped that its work is minimized. Hence it is important both that the construction of the armature element be designed with reference to smallness and consequent lightness of parts, and that its frequency-indicating equipment be of a character imposing the lightest load on the armature. Specifically, the armature laminae 22 are carried on a light disk 23, fixed to the vertical shaft 24, so that is supported by ball bearings 25 and 26, in tube 14, and, above the wall 13, carries the driving member of the indicator device 28. This appliance comprises, as its primary element, 29, a non-magnetic disk 30, of brass, say, having annular spaced, concentric walls 31, and as its secondary element, 32, a pivoted part including very light, annular walls 33 interleaved with the walls 31 and affording extensive smooth friction surfaces, very closely adjacent to, but not contacting with, the kindred surfaces of the primary member so that through the thin films of fluid, preferably air, intervening between them, torque may be transmitted from the primary to the secondary element in substantially linear proportion to the speed of the primary. Posts 35, mounted in the top wall of the frame, support a bridge piece 36 that carries a bearing yoke 37, affording upper and lower jewel bearings 38 and 39, the former contained in a bushing 40 threaded for adjustment in the yoke and set by a nut 41, such bearings receiving the spindle 42 from which extends, rigidly, the arm 43 carrying the annular walls of the secondary element. A spiral spring 44, fixed at one end to the shaft 42 and at its other end clamped adjustably in the split stud 45 on bracket 37, permits rotary displacement of the secondary element, substantially in linear proportion to the force applied. A scale 48, printed on or otherwise affixed to the outermost wall of the secondary element, is graduated in units of frequency and its indication point is determined by a fixed pointer 49 that is fixed at the edge of a transparent sealed window 50 of the casing shell 51 of cup formation, that is secured in sealed relation to the wall 13 as by packed screws 52 engaging bosses 53 on the bridge piece 36 so to complete the hermetic enclosure of the chamber containing the indicating elements. Such hermetic closure is not necessary in many instances but may be desirable.

为了对频率变化做出准确和迅速的响应，作为一个整体，电枢结构 21 及其附件的重量应该非常轻，并且装配成使它的功最小化。因此，重要的是，电枢组件的结构设计要考虑到部件的小和由此带来的轻，并且其频率指示设备要具有在电枢上施加最轻负载的特性。具体地说，电枢叠片 22 由被固定到垂直轴 24 上的盘 23 所携带，轴 24 由管 14 中的滚珠轴承 25 和 26 支撑，并且在壁 13 上方，轴 24 携带指示器装置 28 的驱动构件。该器具包括作为其初级部件 29 的一个非磁性黄铜圆盘 30、具有环形间隔的同心壁 31，以及作为其次级部件 32 的枢转部分，该枢转部分包括与壁 31 交错的非常轻的环形壁 33，该环形壁提供了大量平滑的摩擦表面，这些摩擦表面非常靠近初级部件的类似表面但不接触它们，从而可以通过介于它们之间的流体薄膜（最好是空气），将扭矩与初级部件的速度基本上成线性比例地从初级部件传递到次级部件。安装在框架顶壁中的支柱 35 支撑着携带轴承轭架 37 的桥接件 36，该轴承轭架配有上宝石轴承 38 和下宝石轴承 39，前者被容纳在衬套 40 中，衬套 40 带有螺纹用于在轭架中的调节，并由螺母 41 设定，这种轴承接受心轴 42，携带着初级组件的环形壁的臂 43 从心轴 42 刚性地延伸。螺旋弹簧 44 的一端被固定在轴 42 上，另一端可调整地被夹紧在支架 37 上的裂头螺柱上，该螺旋弹簧允许次级组件的旋转位移基本上与所施加的力成线性比例。印在次级组件最外壁上或以其它方式固定在该最外壁上的刻度 48 以频率为单位进

行刻度，其指示点由一个固定指针 49 确定，该固定指针 49 被固定在杯形外壳 51 的透明密封窗口 50 的边缘，通过与桥接件 36 上的凸台 53 接合的包装螺丝 52，该透明密封窗口 50 以与壁 13 密封的关系被固定在壁 13 上，从而完成容纳指示组件的腔室的气密密封。这种密封在许多情况下不是必需的，但可能是需要的。

In my copending application Serial No. 841,726 filed May 29th, 1914, Patent No. 1,209,359 I have set forth in detail certain laws the observance of which results in attainment of rigorous proportionality of deflections to speed in an "air drag" instrument, and all of such conditions may be observed to advantage in constructing the indication-giving element of the frequency meter.

在我于 1914 年 5 月 29 日提交的序列号为 841,726，专利号为 1,209,359 的待审申请中，我已经详细阐述了某些定律，遵守这些定律会在“空气拖拽”仪器中获得偏转与速度的严格比例，并且所有这些条件可以被观察到有利于构造频率计的指示组件。

It will be noted that an instrument as herein described has many structural and operative advantages. The translating instrument, giving the frequency-reading, when constructed for use of air as the transmitting medium, may be of size to give ample torque, but if desired the ensealed mechanism may be operated in air or other, preferably inert, gases of more than atmospheric density for increase of the torque. The air drag instrument is substantially unaffected in accuracy by temperature changes, without special compensating mechanism, and is therefore practically insensible to the heating effect of the subjacent motor, and the double-chamber construction segregating the motor and translating device prevents the latter from being affected by air-currents engendered by the motor-operation. Furthermore, the indicator structure may be made immune to magnetic influence and eddy currents, however intense, by making its secondary element of appropriate nonshrinkable, insulating material, as compressed fiber, although in many instances the partition 13, acting as a shield for the indicator obviates the necessity for such provision. The small size, low cost and ease of maintenance, due to the simplicity of the construction are especially desirable.

应当注意，这里描述的仪器具有许多结构和操作上的优点。给出频率读数的转换仪器，当被构造成使用空气作为传输介质时，可以具有提供足够扭矩的尺寸，但是如果需要，被密封的机械装置可以在空气中或其它优选的惰性的大于大气密度的气体中操作，以增加扭矩。在没有特殊补偿机械装置的情况下，空气拖动仪器的精度基本上不受温度变化的影响，因此实际上对下层的电动机的热效应不敏感，并且隔离电动机和转换装置的双腔室结构防止后者受电动机运行产生的气流的影响。此外，可以用适当的不可收缩的绝缘材料，如压缩纤维，来制作指示器结构的次级组件，这么做可以使指示器结构免受磁场和涡流的影响，无论这种影响有多强，尽管许多情况下，用于屏蔽指示器的隔板 13 消除了这种设置的必要性。由于结构简单，体积小、成本低和易于维护是特别值得拥有的。

What I claim is:

我主张的是：

1. In a frequency meter, the combination of a synchronous motor, and a speed-responsive device, having a primary element connected to the armature shaft, and a pivoted torsionally-restrained secondary element, deflectable in substantially linear proportion to the speed of the primary and

calibrated in terms of electrical frequency.

1、在一个频率计中，存在一个同步电动机和一个速度响应装置的组合，该组合有一个与电枢轴相连的初级组件和一个受扭转约束的次级组件，该次级组件可与初级组件的速度成线性比例偏转，并根据电频率进行校准。

2. In a frequency meter, the combination of a synchronous motor and a speed-responsive device, said motor having an armature of light construction and said speed-responsive device comprising a primary element carried in rotation by said armature, and a torsionally-restrained secondary element, these elements having extensive confronting, closely adjacent friction surfaces, cooperating through interposed films of a fluid medium for displacement of said secondary element in substantially linear proportion to the speed of rotation of the primary element.

2、在一个频率计中，存在一个同步电动机和一个速度响应装置的组合，所述电动机具有轻型结构的电枢，所述速度响应装置包括由所述电枢带动旋转的初级组件，和一个受扭转约束的次级组件，这些组件具有大面积面对面的、紧密相邻的摩擦表面，通过与介入之间的流体介质薄膜协作，这些组件用于与初级组件的旋转速度基本成线性比例的所述次级组件的位移。

3. In a frequency meter, the combination of a synchronous motor and a speed-responsive device, the former having an armature of light construction and the latter comprising a primary element, carried in rotation by said armature, and a torsionally-restrained secondary element, these elements having extensive confronting, closely adjacent friction surfaces, cooperating through interposed films of air for displacement of said secondary element in substantially linear proportion to the speed of rotation of the primary element, said secondary bearing a scale calibrated in terms of frequency.

3、在一个频率计中，存在一个同步电动机和一个速度响应装置的组合，前者具有轻型结构的电枢，后者包括由所述电枢带动旋转的一个初级组件，和一个受扭转约束的次级组件，这些组件具有大面积面对面的、紧密相邻的摩擦表面，通过与介入之间的流体介质薄膜协作，用于与初级组件的旋转速度基本成线性比例的所述次级组件的位移，该次级组件带有根据频率校准的刻度。

4. A frequency meter comprising, in combination, a synchronous induction motor, having a shell carrying the field, and a rotatable armature within the chamber of said shell having its shaft extended through said shell; and a speed-responsive device, comprising a closed casing, a non-magnetic primary element mounted upon said armature shaft, a separately mounted secondary element pivoted and torsionally restrained, said elements having opposed, closely adjacent non-contacting surfaces, cooperating through interposed films of a fluid medium through which torque is transmitted to the secondary in approximately linear proportion to the speed of the primary member, and a visible scale uniformly graduated in terms of frequency carried by the secondary member.

4、一种频率计，包括：一个同步感应电动机，具有携带磁场的外壳；以及在所述外壳的腔室内的一个可旋转电枢，其轴延伸穿过所述外壳；以及一个速度响应装置，包括一个封闭的壳体，一个安装在所述电枢轴上的非磁性初级组件，一个可转动并受扭转约束的单独安装的次级组件，所述组件具有面对面的、紧密相邻的非接触表面，通过与介入之间的流体介质薄

膜协作，扭矩以与初级组件的速度近似成线性比例的方式传递到次级组件；还有一个根据次级组件所承载的频率均匀分度的可见刻度。

5. A frequency meter comprising a sealed, air-containing casing divided into two compartments, a shaft extending into both compartments, a synchronous motor in one compartment adapted to drive said shaft and an indicating device in the other, said device having a primary rotatable element connected with the shaft, a separately mounted, indication-controlling element and a spring restraining the latter, said elements having extensive, confronting, closely adjacent, non-contacting surfaces cooperating through the interposed air films for displacement of the secondary, at all ordinary temperatures, approximately in linear proportion to the speed of the primary element.

5、一种频率计，包括：被分成两个隔室的密封的、容纳空气的外壳；延伸到两个隔室中的轴；在一个隔室中的同步电机，适于驱动所述轴；在另一个隔室中的指示装置，所述装置具有与所述轴连接的初级可旋转组件；被单独安装的指示控制组件和限制后者的弹簧，所述组件具有延伸的、面对面的、紧密相邻的非接触表面，通过与介入表面之间的空气薄膜进行协作，这些表面用于在所有常温下与初级组件的速度近似成线性比例的次级组件的位移。

6. In a frequency meter, the combination of a synchronous motor having an armature of light construction, a speed-responsive device comprising a primary element carried in rotation by the said armature and a torsionally-restrained secondary element, said elements having extensive confronting closely adjacent friction surfaces cooperating through interposed films of air for displacement of said secondary element in substantially linear proportion to the speed of rotation of the primary element, and a wall interposed between the armature of the motor and the speed-responsive device for shielding the latter from air disturbance caused by rotation of the former.

6、在一种频率计中，包括：一个具有轻型结构电枢的同步电动机；一个包括由所述电枢带动旋转的初级组件和一个受扭转约束的次级组件的速度响应装置，所述组件具有广泛的、面对面的、紧密相邻的摩擦表面，这些摩擦表面通过介入之间的空气薄膜协作，用于使所述次级组件的位移与初级组件的旋转速度基本成线性比例；以及一个插入在电动机电枢和速度响应装置之间的壁，用于保护后者免受前者旋转引起的空气扰动。

7. A frequency meter comprising a casing divided into two compartments, a shaft extending into both thereof, a synchronous motor in one compartment adapted to drive said shaft and a speed-responsive device in the other having a primary element connected for rotation with said shaft, a separately mounted, torsionally-restrained indicating element, said elements having extensive confronting, closely adjacent, non-contacting surfaces cooperating through interposed gaseous films for displacement of the secondary, approximately in linear proportion to the speed of the primary element.

7、在一种频率计中，包括：被分成两个隔室的外壳；延伸到两个隔室中的轴；在一个隔室中的同步电机，适于驱动所述轴；在另一个隔室中的速度响应装置，具有连接成与所述轴一起旋转的初级组件；被单独安装的受扭转约束的指示组件，所述的这些组件具有大面积的、面对的、紧密相邻的非接触表面，通过与介入之间的气体薄膜协作，用于次级组件的位移，该位移近似与初级组件的速度成线性比例。

8. In a frequency meter, the combination of a synchronous motor and a speed-responsive device, said

motor having a light armature and a shaft, and said speed responsive device comprising a primary element of non-magnetic material carried by the armature shaft and a torsionally-restrained secondary element, these elements having extensive, confronting, closely adjacent, non-contacting surfaces cooperating through interposed films of a fluid medium for displacement of the secondary element in approximately linear proportion to the speed of the primary element, and a containing structure en sealing the speed responsive device.

8、在一种频率计中，包括：一个同步电动机和一个速度响应装置的组合，所述电动机具有一个轻型电枢和一个轴；所述的速度响应装置包括由电枢轴携带的非磁性材料的初级组件和受扭转约束的次级组件，这些组件具有延伸的、面对面的、紧密相邻的非接触表面，这些表面通过与介入之间的流体介质膜协作，用于与初级组件的速度成近似线性比例的次级组件的位移；还有密封速度响应装置的一个容器结构。

9. In a frequency meter, the combination of a synchronous motor having an armature of light construction, a speed-responsive device comprising a primary element carried in rotation by the said armature and a torsionally-restrained secondary element, said elements having extensive confronting, closely adjacent friction surfaces cooperating through interposed films of air for displacement of said secondary element in substantially linear proportion to the speed of rotation of the primary element, and means interposed between the armature of the motor and the speed-responsive device for shielding the latter from air disturbance caused by rotation of the former.

9、在一种频率计中，包括：一个具有轻型电枢结构的同步电动机；一个速度响应装置，包括由所述电枢带动旋转的初级组件和一个受扭转约束的次级组件，所述组件具有广泛的、面对面的、紧密相邻的摩擦表面，这些表面通过与介入之间的空气薄膜协作，使所述次级组件的位移基本上与初级组件的旋转速度成线性比例；还有一个工具，它介于电动机电枢和速度响应装置之间，用于保护后者免受前者旋转引起的空气干扰。

In testimony whereof I affix my signature.

我签名为证。

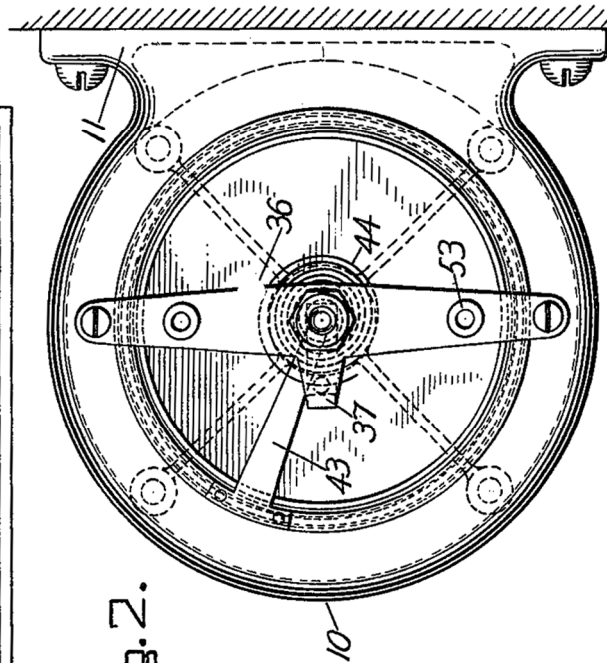
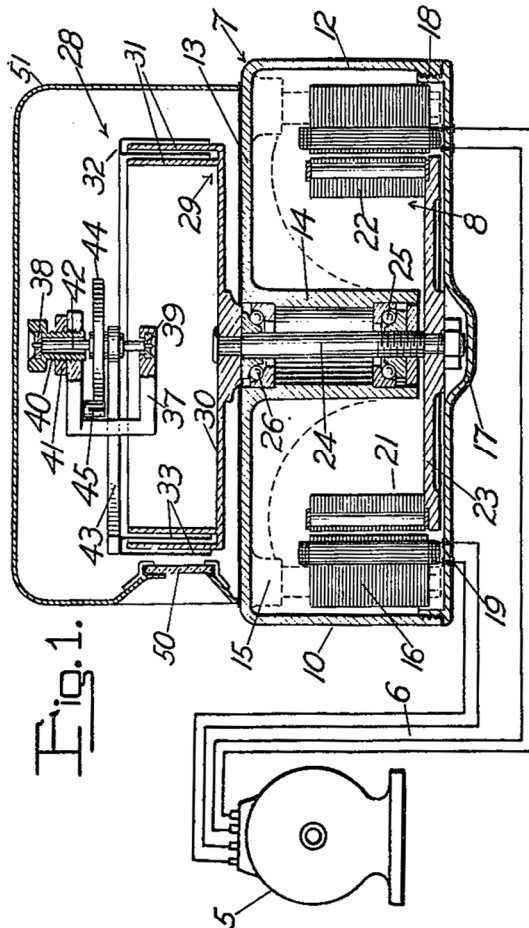
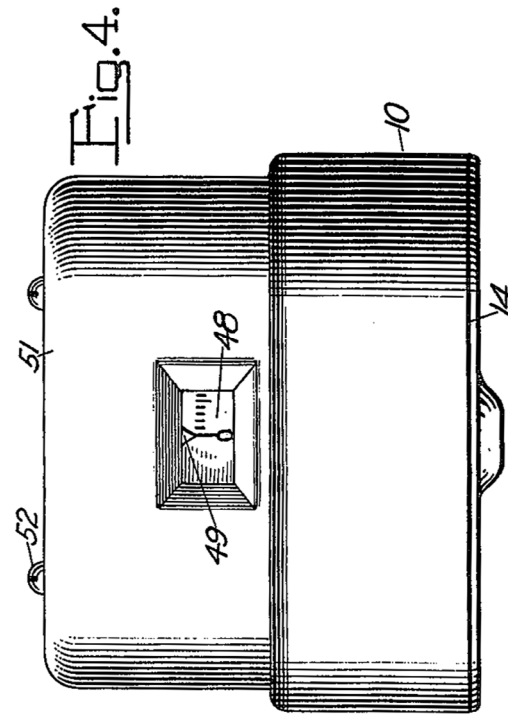
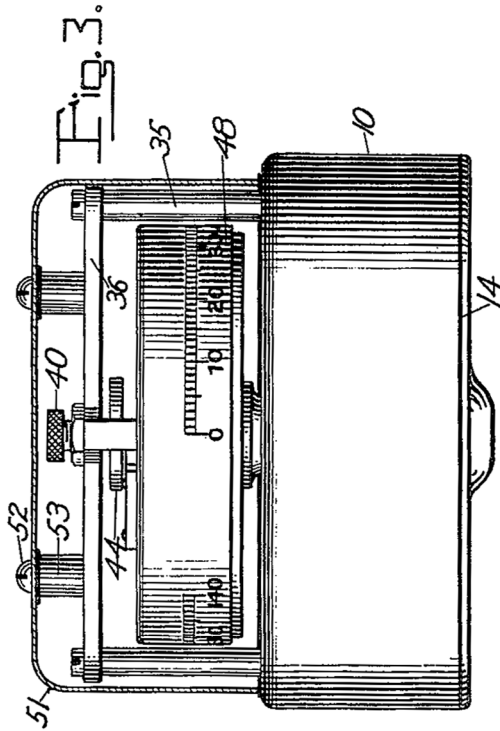
NIKOLA TESLA.

尼古拉·特斯拉

N. TESLA.
FREQUENCY METER.
APPLICATION FILED DEC. 18, 1916.

1,402,025.

Patented Jan. 3, 1922.



Inventor
Nikola Tesla
By his Attorneys
Forie Bainsway

Improved Process of and Apparatus for Production of High Vacua 用于生产高真空的装置的/和改进方法

PATENT SPECIFICATION

179,043

专利说明书第 179,043 号

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完全接受: 1922 年 5 月 4 日

PROVISIONAL SPECIFICATION.

临时说明

I, Nikola Tesla, Mechanical and Electrical Engineer, citizen of the United States of America, of 8, West 40th Street, New York City, U.S.A., do hereby declare the nature of this invention to be as follows:-

我、尼古拉·特斯拉、机械与电气工程师、美利坚合众国公民，居住在美国纽约市西 40 街 8 号，特此声明本发明的性质如下：

In the development of power by thermo-dynamic primemovers, as steam engines and turbines, a low back pressure is essential to good economy, the performance of the machine being increased from fifty to one hundred per cent by reducing the absolute pressure in the exhaust space from fifteen to about one pound per square inch. Turbines are particularly susceptible to such improvement and in their use for operation of power plants and manufacturing establishments the attainment and steady maintenance of high vacua has assumed great importance, every effort being made to better the conditions in this respect. The gain effected by this means is, in a large measure, dependent on the initial pressure, characteristics of the primemover, temperature of the cooling medium, cost of the condensing apparatus and many other things which are all well-known to experts. The theoretical saving of from five to six per cent. of fuel for each additional inch of vacuum is often closely approximated in modern installations, but the economic advantages are appreciably lessened when higher vacua are applied to existing machines purposely designed to operate with lower ones. More especially is this true of a turbine in which the reduction of back pressure merely increases the velocity of exit of the vapors without materially augmenting the speed of their impact against the vanes, buckets, or equivalent organs, when the loss of kinetic energy in the exhaust may offset a considerable portion of the useful work. In such cases some constructional changes in the turbine and auxiliaries may have to be made in order to secure the results here contemplated but the additional capital used for this purpose will be profitably

invested. Summing up the situation it may be generally stated that a more or less substantial reduction of fuel cost can be made in most of the existing power plants by the adoption of proper pumping apparatus and establishment of working conditions nearly corresponding to those of an ideal condenser.

在由热动力原动机（如蒸汽机和涡轮机）产生动力的过程中，低背压对于良好的经济性是必不可少的，通过将抽排空间中的绝对压力从每平方英寸 15 磅降低到大约 1 磅，机器的性能从 50% 提高到 100%。涡轮机特别容易受到这种改进的影响，并且在它们用于发电厂和制造企业的运行中，获得和稳定地保持高真空已经变得非常重要，正在尽一切努力改善这方面的条件。通过这种方式实现的增益在很大程度上取决于初始压力、原动机的特性、冷却介质的温度、冷凝设备的成本以及专家们熟知的许多其他因素。在现代设备中，每增加一英寸真空，理论上可节省 5% 至 6% 的燃料，但当现有的机器采用较高的真空，并被专门设计成以较低的真空运行时，经济优势会明显减弱。尤其是对于涡轮机来说，当抽排中的动能损失可以抵消相当大一部分有用功时，汽轮机中背压的降低仅仅增加了蒸汽的排出速度，而没有实质上增加它们对叶片、扉斗或等效机关的冲击速度。在这种情况下，有可能必须对涡轮机和辅助设备进行一些结构上的改变，以确保此处预期的结果，但用于此目的的额外资本将进行有利可图的投资。总结这种情况，一般可以说，在大多数现有的发电厂中，通过采用适当的泵送设备和建立几乎相当于理想冷凝器的工作条件，可以或多或少地大幅度降低燃料成本。

The chief difficulties which have thus far retarded advancement in this direction are encountered in the enormous volumes of the air and vapor at very low pressures as well as unavoidable leaks in the condenser, pipe joints, valves, glands and stuffing boxes. At present exhaustion is usually accomplished by reciprocating pumps and these, on account of the necessarily low speed of the pistons are large and, moreover, incapable of satisfactory performance in the presence of big leaks. As a direct result of this the condensing plant is both bulky and expensive and, worse still, its size and cost increase entirely in disproportion to the results attained. To illustrate the outlay involved in the instalment of condensing apparatus for a twenty-eight inch vacuum is more than double that required for a vacuum of twenty-six inches and these draw-backs are still more emphasized with the further reduction of the back pressure. Rotary pumps and jets of water and steam are also used in the production of vacua, but without marked qualitative advantages. As to the possible employment of multi-stage centrifugal exhausters, engineers are still in doubt. Such machines have heretofore served only for purposes of compression and it is more than probable that they would prove unsuitable for very high rarefaction. The introduction of Sir Charles Parsons' "vacuum augmentor" and Weir's "dry air" pump was a decided progress towards the desired goal, nevertheless this important problem has only been partially solved and to this day the condensing apparatus is admittedly the most troublesome part of the whole power mechanism, to such an extent, indeed, that its duplication is often deemed not advisable if not absolutely necessary to the safe and reliable working of the plant.

迄今为止，阻碍这一方向发展的主要困难是在非常低的压力下遇到的大量的空气和蒸汽，以及在冷凝器、管接头、阀门、压盖和填料函中不可避免的泄漏。目前，抽排通常是通过往复泵来完成的，由于活塞的速度必须很低，所以往复泵很大，而且在存在大量泄漏的情况下不能达到令人满意的性能。其直接结果是，冷凝设施既庞大又昂贵，更糟糕的是，其尺寸和成本的增加与所获得的结果完全不成正比。为了说明这一点，用于 28 英寸真空的冷凝装置的分期付款费用是用于 26 英寸真空所需费用的两倍以上，并且随着背压的进一步降低，这些缺点更加突出。旋转泵以及水和蒸汽的喷射也被用于产生真空，但没有明显的质量优势。至于多级离心抽排气机的可能应用，工程师们仍存有疑问。迄今为止，这种机器仅用于压缩的

目的，很可能证明它们不适用于非常高的稀薄度。查尔斯·帕森斯爵士的“真空增强器”和韦尔的“干燥空气”泵的引入是朝着预期目标的决定性进展，然而这个重要的问题仅仅被部分地解决了，并且直到今天，冷凝装置被公认为是整个动力机械装置的最麻烦的部分，以至于，事实上，如果冷凝装置对工厂的安全和可靠运行不是绝对必要的话，那么它的复制经常被认为是不可取的。

I have achieved better success in departing from the customary method of removing the air and entrained steam from the condenser by bodily carriers as jets, reciprocating pistons or rotating vanes, and availing myself of the properties of adhesion and viscosity which, according to experimental evidence, are retained by the gases and vapors even at very high degrees of attenuation. The new process which I have thus evolved is rendered practicable through a novel type of pump which I have invented and described in my British Patent No. 24,001 of 1910. This device, suitably modified in certain details of construction and run at the excessive peripheral speed of which an unloaded system is capable, exhibits two remarkable and valuable properties. One of these is to expel the rarefied fluids at such an immense rate that a hole of some size can be drilled in the condenser without much effect on the vacuum gauge. The other is to draw out the fluids until the exhaustion is almost complete. A machine of this kind, constructed in stages, is alone sufficient for the production of extremely high vacua and I believe this quality to be very valuable inasmuch as it is not possessed to such a degree by other types of commercial pumps which have come to my knowledge. This combination is especially advantageous from the practical point of view as good results can be secured with a single stage and the instalment of my device calls for but a slight change in the steam plant. The benefits derived are twofold: a higher vacuum is attained and, what is perhaps more important, the frequent and unavoidable impairments of the same, which seriously affect the economy, are virtually eliminated. My pump makes possible the maintenance of high vacua even when the percentage of air or other fluids carried with the steam is very great and on this account should prove particularly useful in the operation of mixed fluid turbines.

我已经取得了更大的成功，摒弃了通过喷射器、往复式活塞或旋转叶片等流体载体从冷凝器中去除空气和夹带的蒸汽的传统方法，并利用根据实验证据，利用气体和蒸汽的即使在非常高的衰减程度下也保持的黏附性和黏滞性的特性。我发明的新方法通过一种新型的泵变得可行，这种泵是我在1910年的英国专利第24,001号（类似美国专利第1,061,142号和第1,061,206号）中发明和描述的。这种装置，在结构的某些细节上进行了适当的修改，并以空载系统所能达到的过大圆周速度运行，表现出两种显著而有价值的特性。其中之一是以如此巨大的速度排出被稀薄化的流体，以致可以在冷凝器上钻一个一定大小的孔，而不会对真空计产生太大的影响。另一个是抽出流体，直到几乎完全抽排尽。这种机器，被分阶段建造，它足以产生极高的真空，我相信这种品质是非常有价值的，因为据我所知，其他类型的商用泵达不到这种程度。然而，为了避免过度的复杂性和费用，我使用普通的排气装置，并简单地在它和冷凝器之间插入我的泵，该泵吸出被高度稀释化的介质，压缩它并将它输送到“干燥空气”或其他泵。从实用的观点来看，这种结合是特别有优势的，因为用一个步骤就能获得良好的结果，并且我的装置的安装只需要对蒸汽设施进行微小改动。带来的好处是双重的：获得了更高的真空，也许更重要的是，严重影响经济性的频繁和不可避免的更高真空的损害实际上被消除了。即使蒸汽携带的空气或其他流体的百分比非常高，我的泵也可以维持高真空，因此它在混合流体涡轮机的运行中应该被证明是特别有用的。

Dated this 24th day of March, 1921.

日期为 1921 年 3 月 24 日。

Nikola Tesla.
尼古拉·特斯拉

COMPLETE SPECIFICATION.
完整说明书

Improved Process of and Apparatus for Production of High Vacua. 用于生产高真空的装置的/和改进方法

I, Nikola Tesla, Electrical and Mechanical Engineer, citizen of United States of America, of No. 8, West 40th Street, New York, N.Y., U.S.A., do hereby declare the nature of this invention and in what manner the same is to be performed, to be particularly described and ascertained in and by the following statement:-

我、尼古拉·特斯拉、机械与电气工程师、美利坚合众国公民，居住在美国纽约市西 40 街 8 号，特此声明本发明的性质以及执行本发明的方式，将在以下声明中具体描述和确定:-

In the development of power by thermo-dynamic primemovers, as steam engines and turbines, a low back pressure is essential to good economy, the performance of the machine being increased from fifty to one hundred per cent. by reducing the absolute pressure in the exhaust space from fifteen to about one pound per square inch. Turbines are particularly susceptible to such improvement and in their use for operation of power plants and manufacturing establishments the attainment and steady maintenance of high vacua has assumed great importance, every effort being made to better the conditions in this respect. The gain effected by this means is, in a large measure, dependent on the initial pressure, characteristics of the primemover, temperature of the cooling medium, cost of the condensing apparatus and many other things which are all well-known to experts. The theoretical saving of from five to six per cent. of fuel for each additional inch of vacuum is often closely approximated in modern installations, but the economic advantages are appreciably lessened when higher vacua are applied to existing machines purposely designed to operate with lower ones. More especially is this true of a turbine in which the reduction of back pressure merely increases the velocity of exit of the vapors without materially augmenting the speed of their impact against the vanes, buckets, or equivalent organs, when the loss of kinetic energy in the exhaust may offset a considerable portion of the useful work. In such cases some constructional changes in the turbine and auxiliaries may have to be made in order to secure the results here contemplated but the additional capital used for this purpose will be profitable invested. Summing up the situation it may be generally stated that a more or less substantial reduction of fuel cost can be made in most of the existing power plants by the adoption of proper pumping apparatus and establishment of working conditions nearly corresponding to those of an ideal condenser.

在由热动力原动机（如蒸汽机和涡轮机）产生动力的过程中，低背压对于良好的经济性是必不可少的，通过将抽排空间中的绝对压力从每平方英寸 15 磅降低到大约 1 磅，机器的性能从 50%提高到 100%。涡轮机特别容易受到这种改进的影响，并且在它们用于发电厂和制造

企业的运行中，获得和稳定地保持高真空已经变得非常重要，正在尽一切努力改善这方面的条件。通过这种方式实现的增益在很大程度上取决于初始压力、原动机的特性、冷却介质的温度、冷凝设备的成本以及专家们熟知的许多其他因素。在现代设备中，每增加一英寸真空，理论上可节省 5%至 6%的燃料，但当现有的机器采用较高的真空，并被专门设计成以较低的真空运行时，经济优势会明显减弱。尤其是对于涡轮机来说，当抽排中的动能损失可能抵消相当大一部分有用功时，汽轮机中背压的降低仅仅增加了蒸汽的排出速度，而没有实质上增加它们对叶片、庠斗或等效机关的冲击速度。在这种情况下，可能必须对涡轮机和辅助设备进行一些结构上的改变，以确保此处预期的结果，但用于此目的的额外资本将进行有利可图的投资。总结这种情况，一般可以说，在大多数现有的发电厂中，通过采用适当的泵送设备和建立几乎相当于理想冷凝器的工作条件，可以或多或少地大幅度降低燃料成本。

The chief difficulties which have thus far retarded advancement in this direction are encountered in the enormous volumes of the air and vapor at very low pressures as well as unavoidable leaks in the condenser, pipe joints, valves, glands and stuffing boxes. At present exhaustion is usually accomplished by reciprocating pumps and these, on account of the necessarily low speed of the pistons are large and, moreover, incapable of satisfactory performance in the presence of big leaks. As a direct result of this the condensing plant is both bulky and expensive and, worse still, its size and cost increase entirely in disproportion to the results attained. To illustrate - the outlay involved in the instalment of condensing apparatus for a twenty-eight inch vacuum is more than double that required for a vacuum of twenty-six inches and these draw-backs are still more emphasized with the further reduction of the back pressure. Rotary pumps and jets of water and steam are also used in the production of vacua, but without marked qualitative advantages.

迄今为止，阻碍这一方向发展的主要困难是在非常低的压力下遇到的大量的空气和蒸汽，以及在冷凝器、管接头、阀门、压盖和填料函中不可避免的泄漏。目前，抽排通常是通过往复泵来完成的，由于活塞的速度必须很低，所以往复泵很大，而且在存在大量泄漏的情况下不能达到令人满意的性能。其直接结果是，冷凝设施既庞大又昂贵，更糟糕的是，其尺寸和成本的增加与所获得的结果完全不成比例。为了说明这一点，用于 28 英寸真空的冷凝装置的分期付款费用是用于 26 英寸真空所需费用的两倍以上，并且随着背压的进一步降低，这些缺点更加突出。旋转泵以及水和蒸汽的喷射也被用于生产真空，但没有明显的质量优势。

I have achieved better success in departing from the customary method of removing the air and entrained steam from the condenser by bodily carriers as jets, reciprocating pistons or rotating vanes, and availing myself of the properties of adhesion and viscosity which, according to experimental evidence are retained by the gases and vapors even at very high degrees of attenuation. This new process is rendered practicable through a pump, the underlying principle of which is fully explained in my British Patent 24,001 of 1910, but which is modified as hereinafter described and when run at the very great peripheral speed of which an unloaded system is capable, exhibits two remarkable and valuable properties. One of these is to expel the rarefied fluids at such an immense rate that a hole of some size can be drilled in the condenser without much effect on the vacuum gauge. The other is to draw out the fluids until the exhaustion is almost complete. A machine of this kind, constructed in stages, is alone sufficient for the production of extremely high vacua and I believe this quality to be very valuable inasmuch as it is not possessed to such a degree by other types of commercial pumps which have come to my knowledge. I have also found that a very effective combination is produced by inserting my pump between the condenser and a "dry air" or other pump. This combination is especially advantageous

from the practical point of view as good results can be secured with a single stage and the instalment of my device calls for but a slight change in the steam plant. The benefits derived are twofold; a higher vacuum is attained and, what is perhaps more important, the frequent and unavoidable impairments of the same, which seriously affect the economy, are virtually eliminated. My pump makes possible the maintenance of high vacua even when the percentage of air or other fluids carried with the steam is very great and on this account should prove particularly useful in the operation of mixed fluid turbines.

我已经取得了更大的成功，摒弃了通过喷射器、往复式活塞或旋转叶片等流体载体从冷凝器中去除空气和夹带的蒸汽的传统方法，并利用根据实验证据，利用气体和蒸汽的即使在非常高的衰减程度下也保持的黏附性和黏滞性的特性。这种新方法通过一种泵来实现的，其基本原理在我 1910 年的英国专利 24,001(类似美国专利第 1,061,142 号和第 1,061,206 号)中有充分的解释，但如下文所述对其进行了改进，并且当以空载系统所能达到的非常大的圆周速度运行时，表现出两种显著而有价值的特性。这种装置，在结构的某些细节上进行了适当的修改，并以空载系统所能达到的过大圆周速度运行，表现出两种显著而有价值的特性。其中之一是以如此巨大的速度排出被稀薄化的流体，以致可以在冷凝器上钻一个一定大小的孔，而不会对真空计产生太大的影响。另一个是抽出流体，直到几乎完全抽排尽。这种机器，分阶段建造，它足以生产极高的真空，我相信这种品质是非常有价值的，因为据我所知，其他类型的商用泵达不到这种程度。我还发现，通过在冷凝器和“干燥空气”泵或其他泵之间插入我的泵，可以产生非常有效的组合。从实用的观点来看，这种结合是特别有优势的，因为用一个步骤就能获得良好的结果，并且我的装置的安装只需要对蒸汽设施进行微小改动。带来的好处是双重的：获得了更高的真空，也许更重要的是，严重影响经济性的频繁和不可避免的更高真空的损害实际上被消除了。即使蒸汽携带的空气或其他流体的百分比非常高，我的泵也可以维持高真空，因此它在混合流体涡轮机的运行中应该被证明是特别有用的。

My invention will be more fully understood by reference to the accompanying drawings in which Fig. 1 shows a multistage pump of this kind in sectional views, and Fig. 2 illustrates its use in connection with a double-acting reciprocating pump.

通过参考附图，将更全面地理解我的发明，在附图中：图 1 以截面图展示了这种多级泵，图 2 展示了它与双作用往复泵的结合使用。

In the first figure, 1,2,... are rotors each of which, as 1, comprises a number of relatively thin disks 3, 3... separated by starwashers 4, 4... and held together by rigid end-plates 5 and 6 on a sleeve 7 which is fitted and keyed to a shaft 8, rotatably supported in bearings 9, 9. The rotors are contained in separate chambers of a common structure 10 which surrounds them and is made up of parts held together by flange connections. Beginning with the first stage at 1, the rotors diminish in width, each following being made narrower than the preceding, for obvious economic reasons. All the thin discs, as 3, 3... and lefthand end-plates, as 5, are provided with the usual central openings, but the righthand end-plates, as 6, are blank. The individual chambers, containing the rotors, communicate with each other through channels, as 11, extending from the peripheral region of one to the central part of the next, so that the fluids aspirated at the intakes 12, 12 are compelled to pass through the whole series of rotors and are finally ejected at the flanged opening 13 of the last chamber. In order to reduce leakage along the shaft, close-fitting joints or locks, as 14, are employed which may be of ordinary construction and need not be dwelled upon specifically. The number of stages will depend on the peripheral velocity and the degree of exhaustion which it is desired to secure, and in extreme cases a number of separate structures, with

intermediate bearings for the shaft, may have to be provided. When found preferable the pump may be of the double-flow type, when there will be no appreciable side thrust, otherwise provision for taking it up should be made.

在第一幅图中，1、2...是转子，每个转子（如1）包括多个面对面的薄圆盘3、3...这些圆盘由星形垫圈4、4...隔开，并且由套筒7上的刚性端板5和6夹持，套筒7是被定做的并焊接到轴8上，轴8可被旋转地支撑在轴承9、9中。转子被容纳在一个共用结构10的独立腔室中，该共用结构10包围转子，并且是由通过凸缘连接夹持在一起的部件所组成。从1处的第一级开始，转子的宽度减小，由于明显的经济性的原因，每一级都比前一级更窄。所有的薄圆盘，如3、3...和左手端板（如5），设有通常的中心开口，但是右手端板（如6），是未加工的。容纳转子的各个腔室通过通道（如11）彼此连通，这些通道从一个腔室的外周区域延伸到下一个腔室的中心部分，使得在入口12、12处吸入的流体被迫穿过整个一连串的转子，并最终在最后一个腔室的凸缘开口13处喷出。为了减少沿轴的泄漏，采用了紧密贴合的接头或锁，如14，它们可以是普通的结构，不需要特别详述。分级数将取决于外周速度和期望确保的抽排程度，并且在极端情况下，有可能必须提供具有用于轴的中间轴承的多个独立构件。当发现泵是双向流动型是更可取时，此时不会有可察觉的侧推力，否则应做出处理侧推力的准备。

The modifications in details of construction, to which reference has been made, consist in the employment of smaller spaces between the discs than has hitherto been the case, and of close side-clearances. To give a practical example, I may state that spaces of $\frac{3}{64}$ of an inch will be effective in the production of very high vacua with discs of, say, 24 inches in diameter. I also make all discs tapering, when necessary, in order to operate safely at an extremely high peripheral velocity which is very desirable since it reflects both on the size of the machine and its effectiveness.

已经提到的对结构细节的修改包括在圆盘之间采用比迄今为止更小的空间，以及靠近的侧面间隙。给一个实际的例子，我可以说 $\frac{3}{64}$ 英寸的空间对于圆盘（比如说，24 英寸直径）产生非常高的真空将是非常有效的。必要时，我还使所有圆盘朝向边缘逐渐变薄，以便在极高的圆周速度下安全运行，这是非常理想的，因为它反映了机器的大小和效率。

The arrangement represented diagrammatically in Fig. 2 is especially suitable and advantageous in connection with existing steam plants operating with high vacuum and permits the carrying out of my improvements in a simple manner and at comparatively small cost. In this case my pump, which may have but one rotor of the above description, is connected with its intake 12, through a pipe 15, to the top of a condenser 16, and with its discharge opening 13, by pipe 17, to the suction duct, of a reciprocating dry air pump 18. It goes without saying that in actual practice connections 15 and 17 will be short mains of very large section as the volume of fluids to be pumped may be enormous.

在图2中示意性表示的布置对于在高真空下运行的现有蒸汽设备是特别合适和有优势的，并且允许以简单的方式和相对较小的成本实现我的改进。在这种情况下，我的泵可以只有一个上述的转子，泵的入口12通过管道15连接到冷凝器16的顶部，泵的排出口13通过管道17连接到往复式干空气泵18的吸入管。不言而喻，在实际应用中，连接件15和17将是截面非常大的短的主管道，因为要泵送的流体量可能是巨大的。

The operation will be readily understood from the foregoing. The intakes 12 (Fig. 1) being joined by an

air-tight connection to the vessel to be exhausted and the system of discs run at very high peripheral velocity the fluids, by reason of their properties of viscosity and adhesion, are drawn out of the vessel until the degree of rarefaction is attained for which the apparatus has been designed. In their passage through the series of rotors the fluids are compressed by stages and ejected through the opening 13 at a volume greatly reduced. The vacuum produced by this means may be extremely high because of the apparently unique properties of the device pointed out before, and as the fluids, irrespective of their density, are sucked out at an excessive speed, leaks through the glands, stuffing boxes and connections are of but slight effect.

根据前述内容, 运行将很容易理解。入口 12 (图 1) 通过气密连接件连接到要被抽排的容器, 并且圆盘系统以非常高的圆周速度运行, 流体由于其粘性和粘附性而被从容器中抽排, 直到达到该装置所设计的稀薄程度。在流体通过一连串转子的过程中, 流体被逐级压缩, 并以大大减小的体积通过开口 13 喷出。由于之前指出的该装置的明显独特的性质, 通过这种方式产生的真空会非常高, 并且当流体 (不管其密度如何) 以过高的速度被吸出时, 通过填料密封件、填料函和连接件的泄漏影响会很小。

In the arrangement shown in Fig. 2 my pump serves to evacuate the condenser much more effectively and by compressing the fluids at the intake of the reciprocating pump improves the performance of the same. The instalment of the device in existing plants does not call for extensive alterations in the same and will result in a notable saving of fuel. My pump may also be advantageously employed in place of a steam jet in conjunction with a small condenser in which case it will be of insignificant dimensions and economical in steam consumption.

在图 2 所示的布置中, 我的泵用于更有效地抽空冷凝器, 并且通过压缩往复泵入口处的流体来提高其性能。在现有工厂中安装该设备不需要对该设备进行大规模改造, 并且将显著节省燃料。我的泵在代替与小型冷凝器结合的蒸汽喷射器方面也有优势, 在这种情况下, 它的尺寸较小, 消耗蒸汽也很经济。

Having now particularly described and ascertained the nature of my said invention and in what manner the same is to be performed, I declare that what I claim is:-

现在已经特别描述并确定了我的上述发明的性质以及以何种方式执行该发明, 我宣布我主张的是:-

1. The improved process of rarefaction which consists in rotating a disc system communicating with a receptacle and continuously ejecting fluid adhering to said system, until a high vacuum is attained in the receptacle, as described.

1、所述改进的稀薄化过程包括旋转与容器连通的圆盘系统, 并持续喷射黏附在所述系统上的流体, 直到容器中达到高度真空, 如所述。

2. The improved method of exhausting a vessel which consists in rotating a system of discs and continuously applying the frictional force, arising from the viscosity of the fluid and its adhesion to said system, to exhaust the vessel until a high vacuum is attained, substantially as described.

2、一种改进的抽排容器的方法，该方法包括旋转一个圆盘系统，并持续施加摩擦力，该摩擦力是由流体对所述系统的黏滞性和黏附性所产生的，用来抽排容器，直到获得高真空，基本上如所述。

3. The improved process of rarefaction which consists in sucking out of a vessel attenuated fluids by the frictional force of a system of rotating discs, compressing them in the passage through the same, and discharging them into the intake duct of a positively acting pump, as described.

3、一种稀薄化的改进过程，包括通过旋转圆盘系统的摩擦力从容器中吸出稀薄的流体，在通过旋转圆盘的通道中压缩它们，并且将它们排放到一个正在实际工作的泵的入口导管中，如所述。

4. As a means for obtaining high vacua, the combination of apparatus, as illustrated and described.

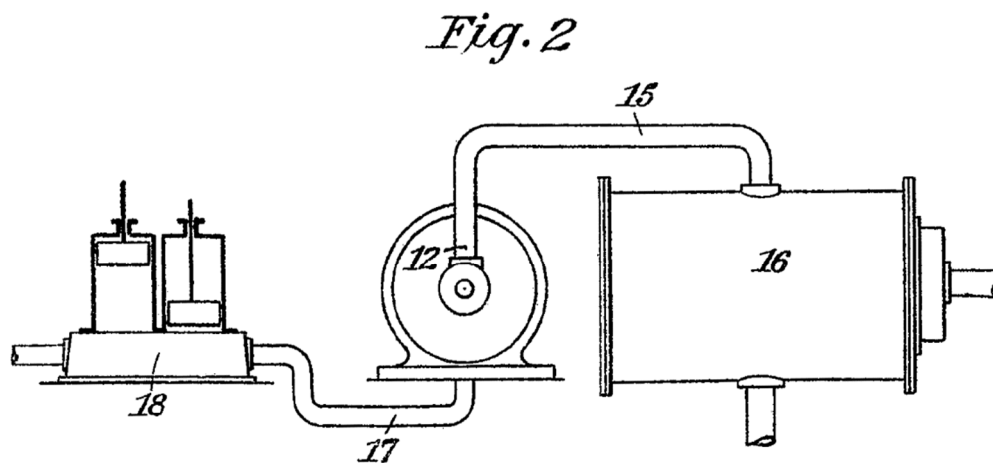
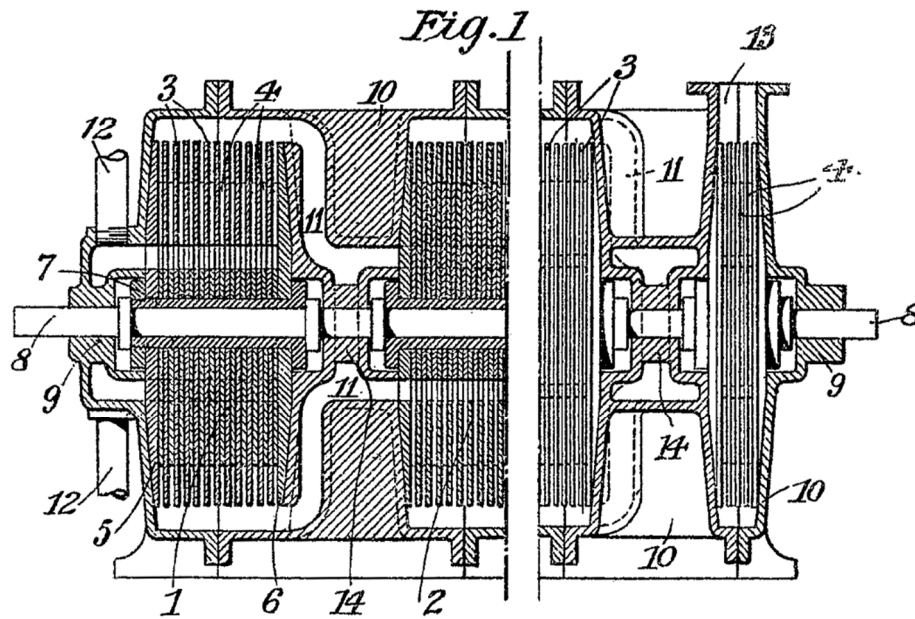
4、作为获得高真空的一种措施，如图所示和所述的装置组合。

Dated the 23rd day of August, 1921.

日期是 1921 年 8 月 23 日。

Nikola Tesla.
尼古拉·特斯拉

[This Drawing is a reproduction of the Original on a reduced scale.]



Improvements in Methods of and Apparatus for the Generation of Power by Elastic Fluid Turbines 用于弹性流体涡轮机发电的装置的/和改进

PATENT SPECIFICATION

185,446

专利说明书第 185,446 号

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完全接受: 1922 年 2 月 2 日

PROVISIONAL SPECIFICATION.

临时说明

I, Nikola Tesla, Mechanical and Electrical Engineer, citizen of the United States of America, of 8, West 40th Street, New York City, U.S.A., do hereby declare the nature of this invention to be as follows:-

我、尼古拉·特斯拉、机械与电气工程师、美利坚合众国公民，居住在美国纽约市西 40 街 8 号，特此声明本发明的性质如下：

In the transformation of the heat of elastic media, by means of turbines, two methods are now extensively employed. In one, the working fluid is expanded through a stationary nozzle and the free jet, impinging against vanes or equivalent devices integral with the rotor, gives up to it velocity energy, thus setting it in motion by action. In the other, the fluid is admitted at full pressure to curved blades or channels in the rotor where it expands imparting energy to the same and causing it to turn by reaction. For well-known technical reasons turbines operating purely on either the first or the second principle are scarcely ever used, both processes being jointly applied in modern machines. Furthermore, almost invariably staging is resorted to with the object of subdividing the velocity - and pressure-drop and improving thereby the performance in conformity with fundamental laws of propulsion.

在利用涡轮机对弹性介质的热量进行转换方面，目前广泛采用两种方法。在一种情况下，工作流体通过一个固定喷嘴发生膨胀，自由射流冲击叶片或与转子构成一体的等效装置，向其释放速度能量，从而通过作用使其运动。在另一种情况下，流体以最高压力进入转子中的弯曲叶片或通道，在那里流体膨胀，将能量传递给叶片或通道，并通过反作用使其转动。由于众所周知的技术原因，纯粹基于第一或第二原理运行的涡轮机几乎从未使用过，这两种方法在现代机器中被联合使用。此外，几乎总是采用分级的方法，目的是细分速度下降和压力下

降，从而改善性能，使之符合推进的基本规律。

As is obvious from theoretical considerations and heat diagrams, the reaction turbine with pressure stages is generally capable of a higher thermo-dynamic efficiency because it has a bigger "reheat factor", that is to say, it transforms into mechanical effort a considerably larger portion of friction heat than recovered in the action turbine, with velocity stages. On the other hand, it will be equally apparent that the former is more limited in the temperature range and, in view of this handicap, its superiority would not be so pronounced were it not for the fact that the relative velocity of the fluid is greater in the latter turbine, this detracting still more from its efficiency.

从理论考虑和加热图解中可以明显看出，具有压力分级的反作用式涡轮机通常具有一个更高的热动力效率，因为它具有更大的“再热系数”，也就是说，与具有速度级的做功涡轮机相比，它将更大部分的摩擦热转化为机械功。另一方面，同样显而易见的是，前者在温度范围内更受限制，鉴于这一缺陷，如果不是因为流体的相对速度在后一种涡轮机中更大的事实，它的优越性不会如此明显，这更有损于它的效率。

These respective qualities and shortcomings have been fully recognized by engineers long ago and have gradually led to the employment of impulse- and reaction-wheels merged into one unit which is thus better adapted for meeting the requirements and should be more economical. But although this idea seems sound, the temperature range has not been very much increased through its application and the gain, so far effected, is moderate indeed, to the point of being doubtful in many instances. Definite limits to progress in this direction have been reached in the existing commercial apparatus and the discovery of other ways and means for saving fuel and reducing the cost of installment and operation has become a problem rendered especially pressing throughout the world by the greatly increased cost of this commodity.

工程师们很久以前就已经充分认识到了这些各自的特性和缺点，并逐渐导致使用合并成一个单元的脉冲轮和反作用轮，从而更好地满足要求，并且应该更经济。虽然这个想法听起来不错，但温度范围并没有通过它的应用大大提高，而且到目前为止所产生的收益确实是平庸的，以至于在许多情况下都值得怀疑。在现有的商业设备中，在这个方向上的进展已经达到了一定的限制，并且发现由于这种商品的成本大大增加，其他节省燃料和降低安装成本和运行成本的方法和手段已成为世界范围内特别紧迫的问题。

The advantages of the action and reaction principles can be more completely realized through a process which constitutes my present invention and, briefly stated, consists in deriving motive power from the heat of an elastic medium first by means of friction and then by reaction. The best instrumentalities for the purpose, of which I am aware, are a turbine of the kind described in my British Patent No. 24,001 of 1910 and one of the Parsons type, both being connected or worked independently. The fluid is admitted to my turbine through a suitable nozzle which may be expanding, straight or converging, and in traversing the spaces between the disks exercises a frictional drag, thus transforming a part of the available heat into mechanical work. Upon exhausting under proper temperature and pressure conditions it is passed through the Parsons turbine in which another portion of its caloric energy is usefully converted by reaction. Careful scientific investigation, supported by experiment, has shown that important economic results can be secured by the new method and that this particular combination of apparatus possesses features of unusual merit.

作用和反作用的原理的优点可以通过构成本发明的一个工艺流程更完整地实现，简而言之，该工艺流程包括首先通过摩擦，然后通过反作用从弹性介质的热量中获得动力。据我所知，最好的工具是我在 1910 年被授予的英国专利第 24,001 号中描述的一种涡轮机和一种帕森斯型涡轮机，两者可以相互连接或者独立地工作。流体通过合适的喷嘴进入我的涡轮，喷嘴可以是扩张的、直的或收拢的，在穿过圆盘之间的空间时产生摩擦阻力，从而将一部分可利用的热量转化为机械功。在适当的温度和压力条件下排气后，流体通过帕森斯涡轮机，在该涡轮机中，流体的卡路里能量的另一部分通过反作用被有效地转化。由实验支持的仔细的科学研究表明，重要的经济性结果可以通过新方法获得，并且这种特殊的设备组合具有不同寻常的优点。

In the first place my turbine is exceedingly suited for very elevated temperatures and also high pressures, while the Parsons excels in the efficiency of the thermo-dynamic transformation at moderate temperatures and low pressures. Again, the former permits the fluid to be expanded either in the nozzle, the rotor or both, and this flexibility facilitates the establishment and maintenance of pressure and temperature conditions favorable to both turbines, thus enhancing economy. Their combination is, however, of quite exceptional value in cases when reversible units are indispensable, as on shipboard, where it provides a simpler, more efficient and far more effective apparatus for forward propulsion as well as backing, my turbine being much better adapted for reversing purposes than other forms with small clearances and delicate blading easily damaged.

首先，我的涡轮机非常适合非常高的温度和高压，而帕森斯型在中等温度和低压下的热动力转换效率方面表现出色。同样，前者允许流体在喷嘴和转子中的一者或者两者中膨胀，这种灵活性有助于建立和保持对两个涡轮机都有利的压力和温度条件，从而提高经济性。然而，在可逆式机组不可或缺的情况下，它们的组合具有非常特殊的价值，如在船上，它提供了一种更简单、更有效和大大有效的向前推进和后退的装置，我的涡轮机比其他具有小间隙和脆弱的易损坏的叶片的发动机形式更适合用于倒转。

While my turbine will yield the best results in co-operation with the Parsons it is eminently qualified to serve as first stage, or stages, in conjunction with other types of turbines, of whatever kind, also with rotating and reciprocating engines, and in this broader sense my improved process may be defined as one in which the available heat of an elastic medium is usefully transformed first by friction, as indicated, and then by action or reaction.

虽然我的涡轮机将在与帕森斯型的合作中产生最好的结果，但它显然有资格作为第一级，或者在其他类型的涡轮机（任何类型）以及旋转式和往复式发动机一起使用中作为多级，并且在这种更广泛的意义上，我的改进进程可以定义为一种弹性介质的有效热量首先通过如所示的摩擦，然后通过作用与反作用进行有用地转化。

Dated this 31st day of March, 1921.

日期为 1921 年 3 月 31 日。

Nikola Tesla.
尼古拉·特斯拉

COMPLETE SPECIFICATION.

完整说明

Improvements in Methods of and Apparatus for the Generation of Power by Elastic Fluid Turbines

用于弹性流体涡轮机发电的装置的/和改进

I, Nikola Tesla, Electrical and Mechanical Engineer, citizen of the United States of America, of 8, West 40th Street, New York, N.Y., U.S.A., do hereby declare the nature of this invention and in what manner the same is to be performed, to be particularly described and ascertained in and by the following statement:-

我、尼古拉·特斯拉、机械与电气工程师、美利坚合众国公民，居住在美国纽约市西 40 街 8 号，特此声明本发明的性质以及以何种方式执行本发明，将在下面的陈述中具体描述和确定：

In the transformation of the heat energy of elastic media, by means of turbines, two methods are now extensively employed. In one, the working fluid is expanded through a stationary nozzle and the free jet, impinging against vanes or equivalent devices integral with the rotor, gives up to it velocity energy, thus setting it in motion by action. In the other, the fluid is admitted at full pressure to curved blades or channels in the rotor where it expands imparting energy to the same and causing it to turn by reaction. For well-known technical reasons turbines operating purely on either the first or the second principle are scarcely ever used, both processes being jointly applied in modern machines. Furthermore, almost invariably staging is resorted to with the object of subdividing the velocity - and pressure-drop and improving thereby the performance in conformity with fundamental laws of propulsion.

在利用涡轮机对弹性介质的热量进行转换方面，目前广泛采用两种方法。在一种情况下，工作流体通过一个固定喷嘴发生膨胀，自由射流冲击叶片或与转子构成一体的等效装置，向其释放速度能量，从而通过作用使其运动。在另一种情况下，流体以最高压力进入转子中的弯曲叶片或通道，在那里流体膨胀，将能量传递给叶片或通道，并通过反作用使其转动。由于众所周知的技术原因，纯粹基于第一或第二原理运行的涡轮机几乎从未使用过，这两种方法在现代机器中被联合使用。此外，几乎总是采用分级的方法，目的是细分速度下降和压力下降，从而改善性能，使之符合推进的基本规律。

As is obvious from theoretical consideration and heat diagrams, the reaction turbine with pressure stages is generally capable of a higher thermo-dynamic efficiency because it has a bigger “reheat factor”, that is to say, it transforms into mechanical effort a considerably larger portion of friction heat than is recovered in the action turbine, with velocity stages. On the other hand, it will be equally apparent that the former is more limited in the temperature range and, in view of this handicap, its superiority would not be so pronounced were it not for the fact that usually the relative velocity of the

fluid is greater in the latter turbine, this detracting still more from its efficiency.

从理论考虑和加热图解中可以明显看出,具有压力分级的反作用式涡轮机通常具有一个更高的热动力效率,因为它具有更大的“再热系数”,也就是说,与带速度级的做功涡轮机相比,它将更大部分的摩擦热转化为机械功。另一方面,同样显而易见的是,前者在温度范围内更受限制,鉴于这一缺陷,如果不是因为流体的相对速度在后一种涡轮机中更大的通常事实,它的优越性不会如此明显,这更有损于它的效率。

These respective qualities and shortcomings have been long recognized by engineers and have gradually led to the employment of impulse and reaction-wheels merged into one unit which is thus better adapted for meeting the requirements and should be more economical. But although this idea seems sound, the temperature range has not been very much increased through its application and the gain, so far effected, is moderate indeed, to the point of being doubtful in many instances. Definite limits to progress in this direction have been reached in the existing commercial apparatus and the discovery of other ways and means for saving fuel and reducing the cost of installation has become a problem rendered especially pressing throughout the world by the greatly increased cost of this commodity.

工程师们早就认识到了这些各自的特性和缺点,并逐渐导致采用将冲量轮和反作用轮合并成一个机组,从而更好地满足要求,并且应该更经济。虽然这个想法听起来不错,但温度范围并没有通过它的应用大大提高,而且到目前为止所产生的收益确实是平庸的,以至于在许多情况下都值得怀疑。在现有的商业设备中,在这个方向上的进展已经达到了一定的限制,并且发现由于这种商品的成本大大增加,其他节省燃料和降低安装成本和运行成本的方法和手段已成为世界范围内特别紧迫的问题。

The economic advantages contemplated can be more completely realized through a process which constitutes my present invention and, briefly stated, consists in converting part of the heat energy of an elastic medium into mechanical work by friction, preferably at a high temperature, and a further part by action or reaction at a lower temperature. The best instrumentalities for the purpose, of which I am aware, are a friction turbine of the kind described in my British Patent No. 24,001 of 1910 and one of the reaction type, such as the Parsons, both being connected or worked independently. The fluid is admitted to my turbine through a suitable nozzle which may be expanding, straight or converging, and in traversing the spaces between the discs exercises a frictional drag, thus transforming a part of the available heat energy into mechanical work. Upon exhausting under proper temperature and pressure conditions it is passed through the reaction turbine in which another portion of its caloric energy is usefully converted by reaction.

通过构成本发明的一个进程,可以更完全地实现预期的经济优势,简而言之,该方法包括通过摩擦将弹性介质的部分热能转化为机械功,最好是在高温下,并且通过在低温下的作用或反作用将另一部分热能转化为机械功。据我所知,最好的工具是我在1910年被授予的英国专利第24,001号中描述的一种涡轮机和一种帕森斯型涡轮机,两者可以相互连接或者独立地工作。流体通过合适的喷嘴进入我的涡轮,喷嘴可以是扩张的、直的或收拢的,在穿过圆盘之间的空间时产生摩擦阻力,从而将一部分可利用的热量转化为机械功。在适当的温度和压力条件下排气后,流体通过帕森斯涡轮机,在该涡轮机中,流体的卡路里能量的另一部分通过反作用被有效地转化。

In the accompanying drawings Fig. 1 is intended to represent my improved turbine and one of the Parsons type operatively joined and with their shafts flexibly connected ; Fig. 2 is a plan view of the same with supply conduits and inlet valves, and Fig. 3 a vertical cross-section of my turbine.

在附图中，图 1 旨在表示我的改进的涡轮机以及各种帕森斯型涡轮机中的一种，它们可以操作性地连接，并且它们的轴被柔性连接；图 2 是具有供给导管和入口阀的相同装置的平面图，图 3 是我的涡轮机的垂直截面图。

Referring to the figures, 1 illustrates the rotor of my turbine enclosed in a casing 2, 2, provided with two inlets 3, 3 for the working medium, nozzles 4 and 5 - one for normal operation and the other for reversal - and two exhaust openings 6, 6 which lead through a conduit 7 to the intake 8 and slide valve 9 of the Parsons turbine 10. The exhaust 11 of the latter communicates through a conduit 12 with the condenser to which is also connected a by-pass 13, branching out from exhaust pipe 7 and equipped with a valve 14. A throttle valve 15 controls the admission of the elastic fluid to my turbine which has, besides, two suitable valves 16 and 17, preferably joined by mechanical means as chain 18, enabling them to be turned together so that one will be closed tight while the other is wide open.

参照附图，1 展示了我的涡轮机的转子，该转子被封装在外壳 2、2 中，该外壳配有两个工作介质入口 3、3，喷嘴 4 和 5(一个用于正常运行，另一个用于反向运行)以及两个排气口 6、6，排气口 6、6 通过导管 7 通向帕森斯涡轮机 10 的入口 8 和滑阀 9。后者的排气口 11 通过一个导管 12 与冷凝器连通，该冷凝器还连接有旁路 13，该旁路从抽排管 7 分支出来并配有阀 14。节流阀 15 控制弹性流体进入我的涡轮机，除此之外，该涡轮机具有两个合适的阀 16 和 17，最好通过机械装置如链条 18 连接，使它们能够一起转动，使得一个紧密关闭，而另一个完全打开。

In normal operation valves 17 and 14 are closed and the medium is admitted to my turbine through valves 15, 16 and nozzle 4, whence it passes through the rotor 1, exhaust openings 6, 6 and pipe 7 to the intake 8 and valve 9 of the Parsons turbine 10 and, after traversing the same, is discharged through exhaust 11 and conduit 12 into the condenser, under which conditions both the turbines are actuated in the same direction, rotation taking place in the sense of the solid arrow Fig. 3. When it is desired to operate in the reverse direction (indicated by the dotted arrow), valves 16 and 9 are closed and 17 and 14 opened wide, the medium entering my turbine through nozzle 5, and after passing through the rotor 1, exhaust openings 6, 6, pipe 7 and by-pass 13, discharges into the condenser. The Parsons turbine is then driven in a direction opposite to its blading but offers a relatively small resistance owing to the vacuum therein; my turbine, on the other hand, develops an amount of power much greater than when working as first described on account of its direct connection with the condenser and correspondingly increased heat drop.

在正常操作中，阀 17 和 14 是关闭的，介质通过阀 15、16 和喷嘴 4 进入我的涡轮机，从那里通过转子 1、排气口 6、6 和管道 7 到达帕森斯涡轮机 10 的进气口 8 和阀 9，并在穿过它们之后，通过抽排口 11 和导管 12 排放到冷凝器中，在这种情况下，两个涡轮机在相同的方向上被驱动，旋转发生在图 3 的实线箭头的方向上。当需要反向操作时(如虚线箭头所示)，阀 16 和 9 关闭，阀 17 和 14 被大大地打开，介质通过喷嘴 5 进入涡轮机，并在通过转子 1、抽排口 6、6、管道 7 和旁路 13 后被排放到冷凝器。帕森斯涡轮机然后在与叶片相反的方向上被驱动，但是由于其中的真空，所以产生相对小的阻力；另一方面，我的涡轮机，由于

它与冷凝器的直接连接和相应提高的热降，产生了比第一次描述时大得多的功率。

Careful scientific investigation, supported by experiment, has shown that important economic results can be secured by the new method and that this particular combination of apparatus possesses features of unusual merit.

由实验支持的仔细的科学研究表明，重要的经济性结果可以通过新方法获得，这种特殊的设备组合具有不同寻常的优点。

In the first place my turbine is especially suited for very elevated temperatures and also high pressures, while the Parsons is particularly adapted to thermo-dynamic transformation at moderate temperatures and low pressures. Again, the former permits the fluid to be expanded either in the nozzle, the rotor or both, and this flexibility facilitates the establishment and maintenance of pressure and temperature conditions favorable to both turbines, thus enhancing economy. Their combination is, however, of quite exceptional value in cases when reversible units are indispensable, as on shipboard, where it provides a simpler and more effective apparatus for forward propulsion as well as backing, my turbine being much more dependable than the present forms with buckets and blades which are very liable to deterioration and easily damaged.

首先，我的涡轮机特别适合非常高的温度和高压，而帕森斯型特别适合中等温度和低压下的热动力转换。同样，前者允许流体在喷嘴和转子中的一者或者两者中膨胀，这种灵活性有助于建立和保持对两种涡轮机都有利的压力和温度条件，从而提高经济性。然而，它们的组合在可逆单元不可或缺的情况下具有非常特殊的价值，如在船上，它提供了一个更简单和更有效的向前推进以及后退的装置，我的涡轮机比其他具有小间隙和脆弱的易损坏的叶片的发动机形式更适合用于倒转。

In the use of different types, as here contemplated, the individual heat drops in them may be considerably varied in magnitude, but to give a practical example I would say that very good results, when working with superheated steam alone, are obtainable by admitting the steam to the nozzle of the friction turbine at about 1100° F. and exhausting it at approximately 550° F. into a reaction turbine capable of operating safely at that temperature.

在使用不同类型的涡轮机时，如这里所设想的，它们中的个体热降在数量上可能有相当大的变化，但为了给出一个实际的例子，我可以说，当单独使用过加热蒸汽时，通过在大约 1100 华氏度下将蒸汽引入摩擦式涡轮机的喷嘴，并在大约 550 华氏度下将其排放到能够在该温度下安全运行的反作用式涡轮机中，可以获得非常好的结果。

While my turbine in such combinations will yield the best results in co-operation with the Parsons, it is eminently qualified to serve as first stage, or stages, in conjunction with other types of turbines, of whatever kind ; also with rotary and reciprocating engines, and in this broader sense my improved process may be defined as one in which the available heat energy of an elastic fluid is usefully transformed first by friction, as indicated, and then by action or reaction.

虽然我的涡轮机将在与帕森斯型的合作中产生最好的结果，但它显然有资格作为第一级，或者在其他类型的涡轮机（任何类型）以及旋转式和往复式发动机一起使用中作为多级，并

且在这种更广泛的意义上,我的改进进程可以定义为一种弹性介质的有效热能首先通过如所示的摩擦,然后通过作用与反作用进行有用地转化。

Having now particularly described and ascertained the nature of my said invention, and in what manner the same is to be performed, I declare that what I claim is:-

现在特别描述和确定了我的上述发明的性质, 以及以何种方式执行, 我宣布我主张的是:-

1. The improved method of thermo-dynamic transformation which consists in converting a part of the heat energy of an elastic fluid by disc friction and a further part by blade action, substantially as described.

1、热动力转换的改进方法在于通过圆盘摩擦转换弹性流体的一部分热能, 并通过叶片作用转换另一部分热能, 基本如所述。

2. The hereinbefore described process of transforming the heat energy of an elastic fluid into rotary mechanical work which consists in converting a part of the energy of the fluid by friction at high temperature and a further part by action and/or reaction at a lower temperature, substantially as described.

2、上文所述的将弹性流体的热能转化为旋转机械功的过程, 包括通过高温下的摩擦转化流体的一部分能量, 以及通过低温下的作用和/或反作用转化另一部分能量, 基本上如所述。

3. In the conversion of heat energy of elastic fluids the combination of the friction and reaction type of turbine, as described.

3、在弹性流体的热能转换中, 摩擦型涡轮机和反作用型涡轮机的组合, 如所述。

4. The combined use of a friction turbine of the kind described with an action and reaction engine in the transformation of the heat energy of elastic fluids into mechanical work.

4、在将弹性流体的热能转化为机械功的过程中, 所描述的这种摩擦涡轮机与一个作用和反作用发动机的结合使用。

5. The combination of a friction turbine of the type described with a turbine of the reaction type mounted on the same shaft or on connected shafts to form an operative unit for the transformation of the heat energy of elastic fluids into mechanical work.

5、所述类型的摩擦式涡轮机与安装在同一轴上或安装在相连轴上的反作用式涡轮机的组合, 以形成将弹性流体的热能转换成机械功的操作机组。

6. The combination of a friction and a reaction turbine of the types described connected to form a power unit so that both may operate together in one direction or be driven in the opposite direction by the friction turbine, the reaction turbine running idle, as described.

6、所述类型的摩擦涡轮机和反作用涡轮机的组合, 这两种涡轮机被连接在一起以形成动力

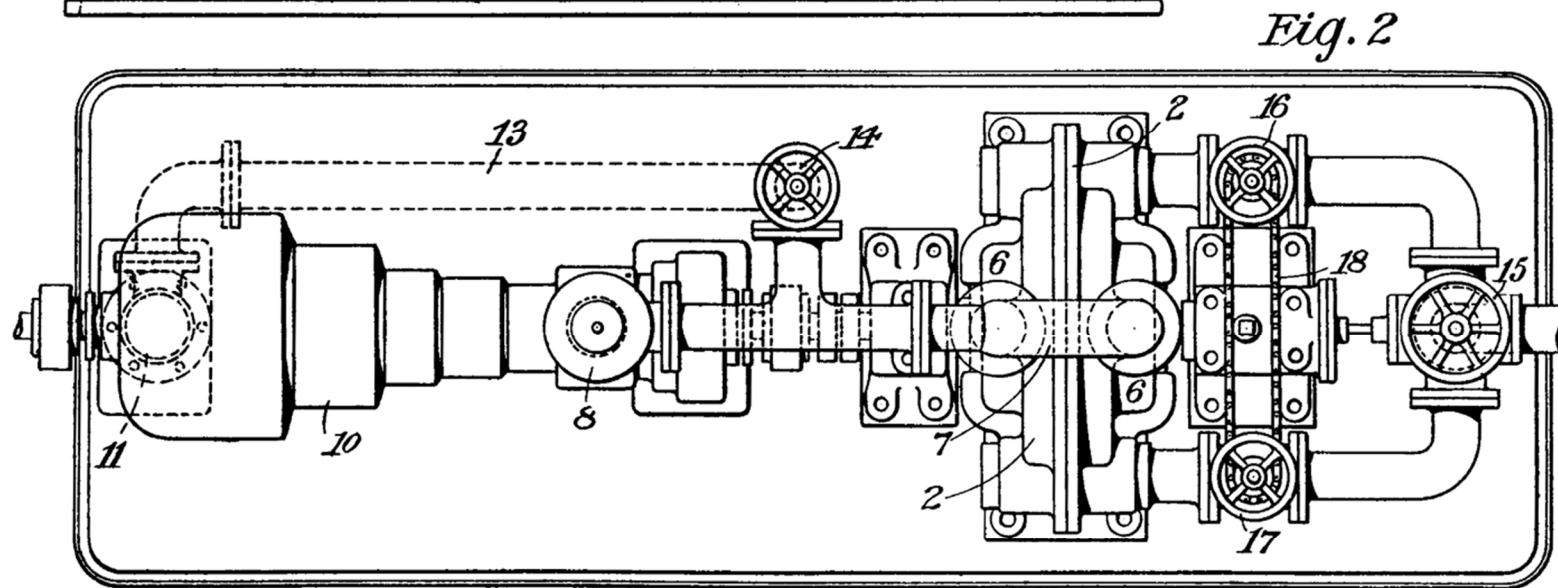
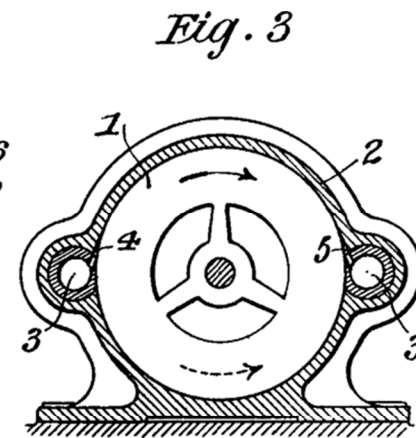
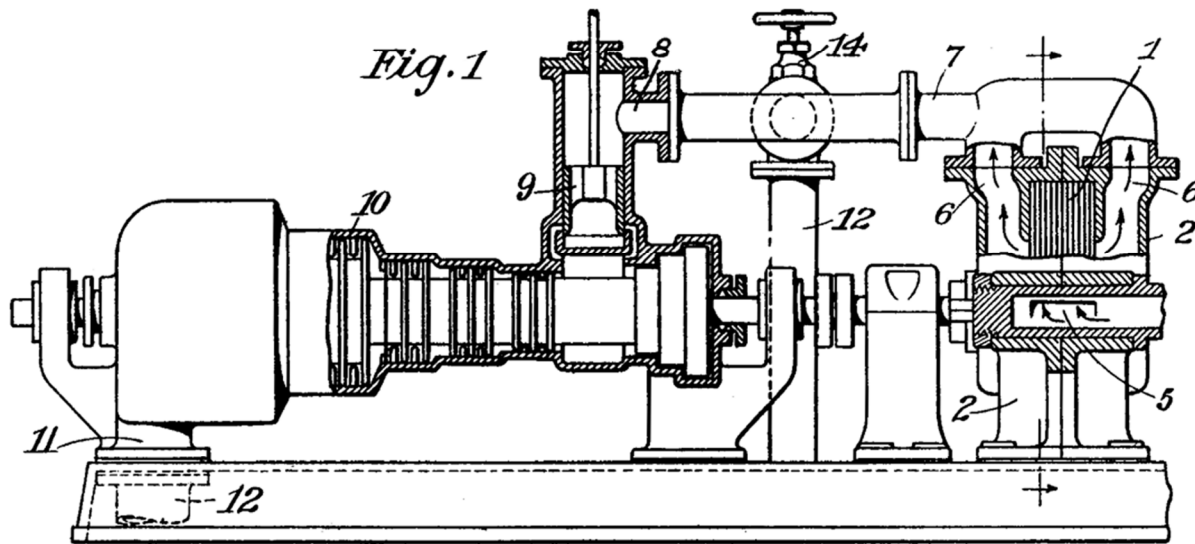
机组，使得两者可以在一个方向上一起运转或者由摩擦涡轮在相反方向上驱动，反作用涡轮机空转，如所述。

Dated the 23rd day of August, 1921.

日期是 1921 年 8 月 23 日。

Nikola Tesla.
尼古拉·特斯拉

2nd Edition



[This Drawing is a full-size reproduction of the Original.]

Improvements in the Construction of Steam and Gas Turbines

蒸汽和燃气涡轮机结构的改进

PATENT SPECIFICATION

186,082

专利说明书第 186,082 号

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完全提交：1921 年 9 月 2 日

完全接受：1922 年 9 月 25 日

PROVISIONAL SPECIFICATION.

临时说明

I, Nikola Tesla, Mechanical and Electrical Engineer, citizen of the United States of America, of 8, West 40th Street, New York City, U.S.A., do hereby declare the nature of this invention to be as follows:-

我、尼古拉·特斯拉、机械与电气工程师、美利坚合众国公民，居住在美国纽约市西 40 街 8 号，特此声明本发明的性质如下：

In a British Patent, Number 24,001 of 1910, I have described a bladeless turbine having a rotor consisting of discs with openings in the central portions and separating star-washers, these parts when assembled being riveted together into a single solid structure and keyed to the shaft. This form of rotor operates satisfactorily but in long experience certain improvements in its construction have been found desirable and these constitute my present invention.

在 1910 年的英国专利第 24,001 号（类似美国专利第 1,061,142 号和第 1,061,206 号）中，我描述了一种无叶片涡轮机，该涡轮机具有一个转子，该转子由在中心部分具有开口的圆盘和独立的星形垫圈组成，当组装它们时，这些部件被铆接在一起成为单一的坚固结构，并被榫接到轴上。这种形式的转子的运行令人满意，但是在长期的经验中，已经发现其结构的某些改进是合乎需要的，并且这些改进构成了我的发明。

In the new design I employ two heavier end-plates which are machined tapering toward the periphery for the purpose of reducing the maximum centrifugal stress as much as practicable. The inside discs, of relatively thin material, are rolled, forged or ground tapering in like manner and with the same object in view, but this may not always be necessary and plates, made of sheet metal of substantially uniform thickness as furnished by the mills, can be employed. Each of the thick as well as thin plates is provided

with exhaust openings, leaving a solid central portion like the hub and spokes of a wheel. Star-washers of similar configuration serve the purpose of keeping the discs apart in the center and for the peripheral spacing the thin plates have small holes drilled in them on a circle, or circles, of suitable diameter, and in these are driven tight-fitting studs which are upset at both ends by a special tool so that they will project beyond the metal on each side a trifle more than the thickness of the star-washers. When the plates are put together the separating studs do not come in line but are straddled in order to give opportunity for slight yielding, thereby eliminating constructional difficulties which might be caused by unevenness or other mechanical imperfections. Thus the rotor can be finished closely to predetermined overall dimensions and will run true on the outside even if the thin inside plates should vary a little in thickness or be slightly warped. To simplify this arrangement I provide only every second plate with studs, using plain ones between. Furthermore, with the object of cheapening the manufacture I dispense altogether with the former, accomplishing the spacing by means of small bosses or protuberances which are raised in the plates by blows or pressure and provide a die, practically reducing all the machine work on a thin plate to a single operation in a stamping press. The star-washers, while preferable, are not indispensable and may be replaced by round separating washers of a diameter about equal to that of the hub part of the discs.

在新的设计中，我采用了两个较重的端板，它们被加工成向外周逐渐变薄，以尽可能减少最大离心应力。相对较薄材料制成的内盘以类似方式轧制、锻造或磨削成锥形，目标是相同的，但这并不总是必要的，可以采用由轧机提供的厚度基本均匀的金属板制成的板。每块厚板和薄板都设有抽排口，留下一个实心的中心部分，就像车轮的轮毂和辐条一样。类似配置的星形垫圈用于保持圆盘在中心被隔开，对于外周间距，薄板在一个或多个适当直径的圆上钻有小孔，在这些小孔中是从动的紧密贴合的螺柱，螺柱两端用特殊工具镦粗，使其伸出每侧的金属超过星形垫圈的厚度一点点。当板被放在一起时，独立的螺柱不在一条直线上，而是交错在一起，以便提供轻微弯曲的机会，从而消除可能由不平坦或其他机械缺陷引起的结构困难。因此，转子可以被加工成接近预定的整体尺寸，并且即使薄的内侧板在厚度上有一点变化或者稍微翘曲，也可以在外侧上运行。为了简化这种布置，我只是在每隔一个板上配备螺柱，在它们之间使用普通的螺柱。此外，为了降低制造成本，我完全放弃了前者，通过小凸台或突起来实现间隔，这些小凸台或突起是通过在板上击打或挤压和冲模来形成的，实际上将薄板上的所有机械加工减少到冲压机中的单一操作。星形垫圈虽然是首选，但不是必不可少的，可以用直径约等于圆盘的轮毂部分直径的圆形分隔垫圈来代替。

All the plates and washers are fitted on and keyed to a sleeve threaded at the ends and equipped with nuts and collars for drawing the thick end-plates together or, if desired, the collars may be simply forced onto it and the ends upset. The sleeve has a hole fitting snugly on the shaft and is fastened to the same as usual.

所有的板和垫圈都与套筒贴合并榫接在套筒上，套筒的端部有螺纹，并配有螺母和套环，用于将厚端板靠拢在一起，或者如果需要，可以简单地将套环压在套筒上并将端部镦粗。套筒上有一个孔，正好贴合在轴上，套筒像往常一样被固定在轴上。

This construction permits free expansion and contraction of each plate individually under the varying influence of heat and centrifugal force and possesses a number of other advantages which are of considerable practical moment. A larger active plate area and consequently more power is obtained for a given width, this improving efficiency. Warping is virtually eliminated and smaller side clearances may

be used which results in diminished leakage and friction losses. The rotor is better adapted for dynamic balancing and through rubbing friction resists disturbing influences thereby insuring quieter running. For this reason and also because the discs are not rigidly joined it is safer against damage which might otherwise be caused by vibration or excessive speed.

这种结构允许每个板在热和离心力的不同影响下自由膨胀和收缩，并具有许多其它优点，这些优点具有相当大的实用价值。对于给定的宽度，可以获得更大的有效板面积，从而获得更大的功率，这提高了效率。翘曲实际上被消除，并且可以使用较小的侧间隙，这导致泄漏和摩擦损失减少。转子更适于动态平衡，并通过摩擦抵抗干扰影响，从而确保更安静的运行。由于这个原因，也因为盘不是刚性连接的，所以可以更安全地防止由振动或过快速度引起的损坏。

Dated this 24th day of March, 1921.

日期为 1921 年 3 月 24 日。

Nikola Tesla.
尼古拉·特斯拉

COMPLETE SPECIFICATION.

完整说明

Improvements in the Construction of Steam and Gas Turbines

蒸汽和燃气涡轮机结构的改进

I, Nikola Tesla, Electrical and Mechanical Engineer, citizen of the United States of America, of No. 8, West 40th Street, New York, N.Y., U.S.A., do hereby declare the nature of this invention and in what manner the same is to be performed, to be particularly described and ascertained in and by the following statement: -

我、尼古拉·特斯拉、机械与电气工程师、美利坚合众国公民，居住在美国纽约市西 40 街 8 号，特此声明本发明的性质以及执行本发明的方式，将在以下声明中具体描述和确定:-

In a British Patent, No. 24,001 of 1910, I have described a bladeless turbine having a rotor consisting of discs with openings in the central portions, and separating star-washers, these parts when assembled being riveted together into a single solid structure and keyed to the shaft. This form of rotor operates satisfactorily but in long experience certain improvements in its construction have been found desirable and these constitute my present invention.

在 1910 年的英国专利第 24,001 号（类似美国专利第 1,061,142 号和第 1,061,206 号）中，我描述了一种无叶片涡轮机，该涡轮机具有一个转子，该转子由在中心部分具有开口的圆盘和独立的星形垫圈组成，当组装它们时，这些部件被铆接在一起成为单一的坚固结构，并被榫接

到轴上。这种形式的转子的运行令人满意，但是在长期的经验中，已经发现其结构的某些改进是合乎需要的，并且这些改进构成了我的发明。

In the new design, illustrated in the accompanying drawings Fig. 1 and Fig. 2, respectively showing a section through the rotor on line I-I and a side view partly broken away exposing a portion of a star-washer, I preferably employ two heavier end-plates 1, 1 of suitable material made tapering on the outside toward the periphery, as shown, for the purpose of reducing the maximum centrifugal stress as much as practicable. The inside discs 2, 2 are relatively thin and may be tapered on both sides in the peripheral part beyond the star-washers with the same object in view, but plates of substantially uniform thickness, as furnished by the mills, can also be employed. Each of the plates - thick as well as thin - is provided with exhaust openings 3, 3 leaving a solid central portion 4, 4 like the hub and spokes of a wheel. If there is an odd number of thin plates the central one may be plain, if desired. Star-washers 5, 5 of similar configuration, and projecting with their arms considerably beyond the exhaust openings, serve the purpose of keeping the discs apart in the central region and for the peripheral spacing the thin plates have small holes drilled in them preferably on a circle, or circles, of suitable diameter, and in these are driven tight-fitting spacers or studs 6, 6 which may be upset at the ends so that they will project on each side a trifle more than the thickness of the star-washers 5, 5 When the plates are put together the separating studs do not come in line but are straddled, as indicated in Fig. 1 and in the broken away part of Fig. 2 by the plain and dotted small circles, in order to give opportunity for slight yielding, thereby eliminating constructional difficulties which might be caused by unevenness or other mechanical imperfections. Such a rotor can be finished closely to predetermined overall dimensions and will run true on the outside even if the thin inside plates should vary a little in thickness or be slightly warped. To simplify the construction I provide only every second plate with studs, using plain ones between. Furthermore, with the object of cheapening the manufacture, I may dispense with the studs altogether, accomplishing the peripheral spacing by means of other spacers such as small bosses or protuberances raised in the plates, thus reducing the machine work on the thin ones to a single operation in a stamping press. The star-washers, while preferable, are not indispensable and may be replaced by round separating washers of a diameter about equal to that of the hub part of the discs.

在新的设计中，如图 1 和图 2 所示，这两幅图分别展示了沿线 I-I 穿过转子的截面图和部分剖开的侧视图，露出了星形垫圈的一部分，为了尽可能减小最大离心应力，我首选采用两个由合适材料制成的较重的端板 1、1，如图所示，端板 1、1 在外侧朝向外周逐渐变薄。内盘 2、2.... 相对较薄，并且可以在星形垫圈之外的外周部分的两侧逐渐变薄，以达到相同的目的，但是也可以使用由工厂提供的厚度基本均匀的板。每块厚的和薄的板都设有排气口 3、3.... 留下实心的中心部分 4、4.... 就像车轮的轮毂和辐条。如果有奇数个薄板，如果需要的话，中心的薄板可以是平的。星形垫圈 5、5.... 具有相似的结构，并且它们的臂突出超过排气口很多，用于保持盘在中心区域被隔开，并且对于外周间隔，薄板具有钻出的小孔，最好在具有适合的直径的一个或多个圆上，并且在这些孔中有从动的紧密贴合的垫片或螺柱 6、6.... 这些垫片或螺柱可以在端部被镦粗，使得它们将在每一侧的突出量比星形垫圈 5、5.... 的厚度大一点。当板被放在一起时，独立的螺柱不在一条直线上，而是交错在一起，如图 1 和图 2 的剖开部分中由简单的小圆圈和虚线所示，以便提供轻微弯曲的机会，从而消除可能由不均匀性或其他机械缺陷引起的结构困难。这种转子可以加工成接近预定的整体尺寸，并且即使薄的内侧板在厚度上有一点变化或者稍微翘曲，也可以在外侧运行。为了简化这种布置，我只是在每隔一个板上配备螺柱，在它们之间使用普通的螺柱。此外，为了降低制造成本，我完全

放弃了螺柱，通过小凸台或突起来实现外周间隔，这些小凸台或突起是通过在板上击打或挤压和冲模来形成的，实际上将薄板上的所有机械加工减少到冲压机中的单一操作。星形垫圈虽然是首选，但不是必不可少的，可以用直径约等于圆盘的轮毂部分直径的圆形分隔垫圈来代替。

All the plates and washers are fitted on and keyed to a sleeve 7, threaded at the ends and equipped with nuts 8, 8 for drawing the thick end-plates together or, if desired, the nuts and threads on the sleeve may be omitted, collars forced on its ends and the same upset. The sleeve fits snugly on the shaft 9 and is fastened to it as usual.

所有的板和垫圈都贴合套筒 7 并与套筒 7 榫接，套筒 7 的端部带有螺纹，并配有螺母 8，螺母 8 用于将厚端板靠拢在一起，或者如果需要，套筒上的螺母和螺纹可以省略，轴环压在套筒的端部并进行相同的镗粗。套筒紧密贴合在轴 9 上，并像往常一样被固定在轴 9 上。

This construction enables the use of thinner inside plates than practicable in the earlier form, thus affording a greater active surface and increasing correspondingly the output, while the smaller clearances are instrumental in reducing the leakage losses.

这种结构能够使用比早期形式更薄的内板，从而提供更大的有效表面并相应地增加输出，而更小的间隙有助于减少泄漏损失。

Having now particularly described and ascertained the nature of my said invention and in what manner the same is to be performed, I declare that what I claim is:-

现在特别描述和确定了我的上述发明的性质和以何种方式执行，我宣布我主张的是:-

1. A rotor for steam and gas turbines composed of plane spaced discs and two rigid end-plates holding them in fixed position laterally but permitting their independent expansion or contraction in the radial direction, said discs and plates being provided with exhaust openings in their central portions, substantially as described.

1、一种用于蒸汽和燃气涡轮机的转子，由平面间隔的圆盘和两个刚性端板组成，这两个刚性端板将圆盘横向保持在固定位置，但允许它们在径向方向独立地扩张或收缩，所述圆盘和板在它们的中心部分设有抽排口，基本上如所述。

2. A turbine rotor comprising plane discs with spacers allowing radial displacement, central separating washers and two rigid tapering end-plates for holding the structure firmly near the shaft, said discs and end-plates having exhaust openings in their central portions, substantially as described.

2、一种涡轮转子，包括具有允许径向位移的垫片的平面圆盘、中心独立垫圈和两个刚性锥形端板，该端板用于将该结构牢固地保持在轴附近，所述圆盘和端板在其中心部分具有抽排口，基本上如所述。

3. In a rotor for high-speed turbines plane spaced discs with exhaust openings in their central portions and tapering towards the periphery as, and for the purpose described.

3、在用于高速涡轮机的转子中，被平面间隔的且在中心部分具有抽排口的圆盘，并且为了所描述的目的，朝着外周逐渐变薄。

4. A turbine rotor consisting of a system of discs held apart by spacers in frictional contact with them and alternately straddled as, and for the purpose, described.

4、一种涡轮转子，由一个圆盘系统组成，圆盘通过垫片被分开夹持，垫片与圆盘摩擦接触，并且为了所描述的目的交错布置。

5. A turbine rotor composed of plane parallel discs having exhaust openings in their central portions and projections for holding them apart near the periphery, substantially as described.

5、一种由平面平行的圆盘组成的涡轮转子，该圆盘在其中心部分具有抽排口和用于在外周附近将它们保持隔开的突起，基本上如所述。

6. In a turbine rotor composed of flat discs with exhaust openings in their central portions, star washers of similar configuration and projecting with their arms considerably beyond the openings in the discs, substantially as described.

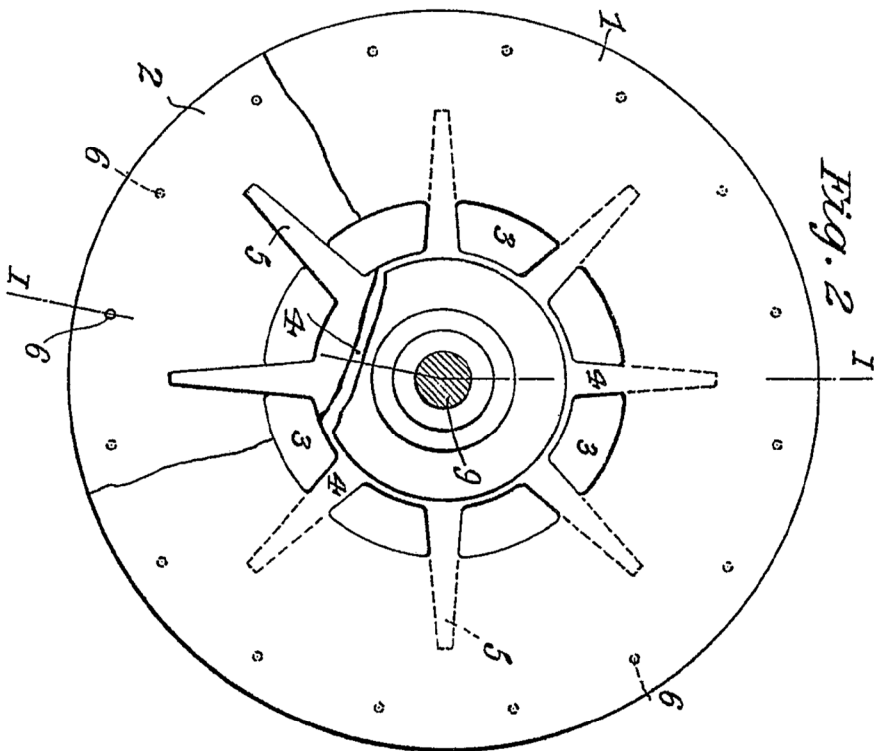
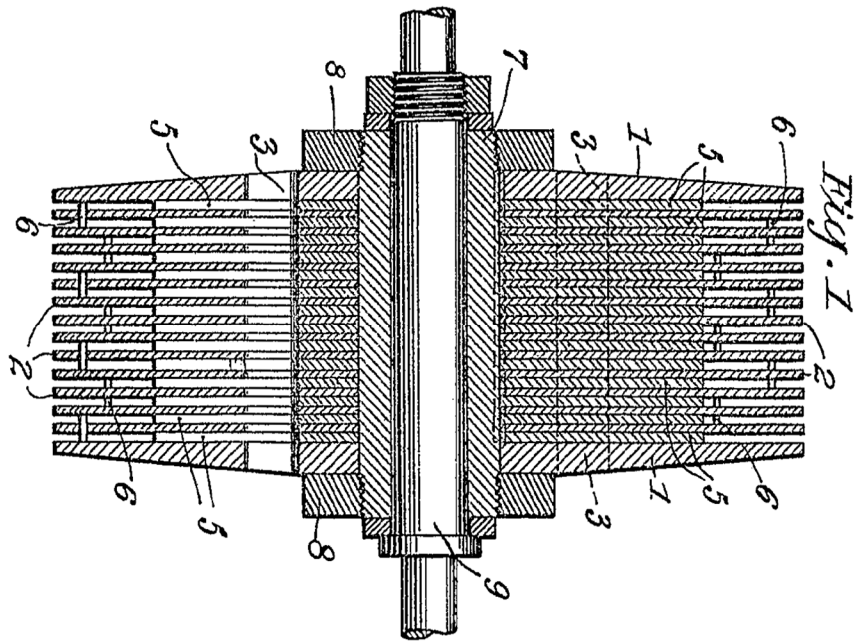
6、在由平坦圆盘组成的涡轮转子中，该圆盘在其中心部分具有抽排口，星形垫圈具有相似的结构，并且其臂明显超出圆盘的开口，基本上如所述。

Dated the 23rd day of August, 1921.

日期是 1921 年 8 月 23 日。

Nikola Tesla.
尼古拉·特斯拉

[This Drawing is a full-size reproduction of the Original]



Improved Method of and Apparatus for the
Economic Transformation of the Energy of
Steam by Turbines.
通过涡轮机经济地转换蒸汽能量的装置的/
和改进方法

PATENT SPECIFICATION

186,083

专利说明书第 186,083 号

Application Date: Mar. 24, 1921. No. 9099/21.

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申请日期: 1921 年 3 月 24 日。编号 9099/21。

完全提交: 1921 年 9 月 5 日

完全接受: 1922 年 9 月 25 日

PROVISIONAL SPECIFICATION.

临时说明

I, Nikola Tesla, Mechanical and Electrical Engineer, citizen of the United States of America, of 8, West 40 Street, New York City, U.S.A., do hereby declare the nature of this invention to be as follows:-

我、尼古拉·特斯拉、机械与电气工程师、美利坚合众国公民，居住在美国纽约市西 40 街 8 号，特此声明本发明的性质如下：

The chief object of my improvements is to increase the efficiency of the existing steam power plants and thermo-dynamic transformers operated therefrom, but they may also be applied with like effect apart from the present establishments and are intended for the broad purpose of producing motive power, more economically, through the medium of steam.

我的改进的主要目的是提高现有的蒸汽动力装置和热动力转换器的效率，但是除了现有的设施之外，它们也可以以类似的效果被应用，并且它们旨在更经济地通过蒸汽介质生产动力并用于广泛的目的。

It is well-known that notwithstanding the multiplication of hydro-electric and gas engine installations, steam is still the main source of power, but as a rule only a low fuel efficiency is secured owing to limitations inherent to the thermal process itself, as now carried out, and certain shortcomings of the present forms of apparatus. Furthermore, plans which have been heretofore contemplated for the attainment of better economy generally involved technical obstacles, more or less radical changes and

necessarily considerable expense. For instance, in order to minimize the heat losses incident to the raising of steam, it has been suggested to burn the fuel together with air in the boiler and operate the engines by the mixture of steam and gas thus obtained. So far, however, attempts to effect combustion satisfactorily under such conditions have not been very successful. High pressures have been proposed with the same end in view but no great progress has yet been made in that direction; in fact many engineers view such projects with disfavor as they present a number of objectionable features and the possibilities of improvement are circumscribed. Again the employment of superheat as a means of increasing fuel efficiency is practicable only in a measure because the adopted types of prime movers do not lend themselves to high temperatures which, in conformity with the fundamental laws of thermodynamics, are indispensable to such a full realization.

众所周知，尽管水力发电装置和燃气发动机装置成倍增加，蒸汽仍然是主要的动力来源，但是由于现在进行的热处理本身固有的限制以及现有设备形式的某些缺点，通常只能获得较低的燃料效率。此外，迄今为止为获得更好的经济性而考虑的方案通常涉及技术障碍、或多或少彻底的改变和必然相当大的费用。例如，为了使产生蒸汽的热损失最小化，有人建议在锅炉中将燃料与空气一起燃烧，并通过由此获得的蒸汽和燃气的混合物来运行发动机。然而，到目前为止，在这种条件下想要令人满意地进行燃烧的尝试还不是很成功。出于同样的目的，已经提出了高压，但在这个方向上尚未取得重大进展；事实上，许多工程师不喜欢这样的项目，因为它们呈现出许多令人讨厌的特征，并且改进的可能性受到限制。同样，过饱和温度作为提高燃料效率的一种手段仅在一定程度上是可行的，因为所采用的原动机类型不适合于高温，但根据热力学的基本定律，高温对于完全实现提高燃料效率是必不可少的。

These drawbacks have been successfully overcome in the method I have devised, which is very economical, readily applicable to the plants now in operation without appreciable modifications in them, and is rendered particularly advantageous through the instrumentality of a turbine or rotary engine described in my British Patent No. 24,001 of 1910 and improvements I have made in its construction since that time. This machine is capable of operating satisfactorily at very high temperatures, with cheap fuel, containing a large percentage of impurities, and without substantial impairment of efficiency as might be due to oxidation, roughening of the metal surfaces, or similar deteriorating actions which seriously interfere with the working of other heat engines now in use.

这些缺点已经在我设计的方法中成功地克服了，该方法非常经济，容易应用于现在正在运行的装置中，而不需要对它们进行明显的修改，并且该方法通过我在 1910 年的被授予的英国专利第 24,001 号中描述的涡轮机或旋转发动机的方法以及我从那时起对其结构进行的改进而变得特别有优势。这种机器能够在非常高的温度下令人满意地运行，使用廉价的燃料，燃料含有大百分比的杂质，并且没有由于氧化、金属表面粗糙化或类似的严重干扰现在使用的其他热力发动机的工作的退化行为而导致的对效率的实质性损害。

In applying my invention to a steam power plant I use air, under a pressure about equal to that of the boiler, for burning gas, crude oil, colloidal fuel or powdered coal in a chamber or conduit into which the steam is simultaneously admitted as cooling agent and diluent. The provisions to this end will greatly vary according to conditions. In central stations, factories, on shipboard and in many other places compressed air, as well as steam, is available and often, too, all the facilities for fuel storage and supply may be on hand. In such cases the benefits of my improvements will be readily derived with but little additional apparatus and at small cost. If the circumstances require, I provide an air-and also a gas

compressor when necessary, driven directly from the shaft of the prime-mover or operated independently by electricity, steam or other motive agent. Generally these machines will be of the more efficient reciprocating type, but rotary compressors or both may be employed to secure some advantage. Irrespective of specific arrangements I effect the combustion while the fluids are in rapid motion and in a conduit preferably in close proximity to the engine, thus disposing of most of the difficulties previously encountered and at the same time materially reducing the radiation and conduction losses which would be incurred in the passage through long pipes. To better insure the maintenance of standard working conditions I may add to the equipment an equalizer of pressures operated differentially by the air and steam, but this device is not essential. The quantity of steam is so regulated that the highly heated mixture, upon expansion through the nozzle, attains an arbitrary temperature which the turbine can safely withstand. The elastic fluids, after traversing the rotor and giving up to the same a part of their kinetic energy, escape through the exhaust openings and serve the further purpose of preheating the feedwater, fuel, and likewise the air when desired. If intensely heated, the air and fuel will be conveyed to the combustion chamber separately, but in small installations it may be convenient to feed the fuel into the compressor or air pipe leading the carburated medium to the chamber. When simplicity is paramount, cheap coils or heaters for the combustibles and the feedwater will be resorted to, but in order to attain a still higher thermal efficiency I employ, besides, a small auxiliary boiler through which the exhaust is circulated. The steam thus obtained from waste heat is fed through a suitable valve, opening at the proper pressure, into the combustion space whence it passes, together with that furnished by the plant, through the turbine first doing useful work and then adding to the waste heat to be utilized in the manner set forth. More fuel may now be gradually admitted to maintain the normal temperature, this again increasing the heat in the exhaust and causing a more rapid generation of the steam, and so on, until finally a steady regime is established. However, if deemed of advantage under given operative conditions, the steam from the main boiler may be reduced in quantity in approximately the same measure as that from the auxiliary boiler is supplied.

在将我的发明应用于蒸汽动力装置时,我使用压力大约等于锅炉压力的空气,在一个室或导管中燃烧气体、原油、胶体燃料或煤粉,蒸汽同时作为冷却剂和稀释剂进入该室或导管。这方面的配备将因条件不同而有很大差异。在中心电站、工厂、船上和许多其他地方,压缩空气和蒸汽都是可用的,而且通常所有的燃料储存和供应设施都在场。在这种情况下,我的改进的好处将很容易获得,只需很少的额外设备和很小的成本。如果情况需要,我提供一个空气压缩机,必要时也提供一个燃气压缩机,直接由原动机的轴驱动或由电、蒸汽或其他动力剂独立运行。一般来说,这些机器将是更有效的往复式,但旋转压缩机或两者都可以使用,以确保某种优势。不考虑具体的布置,当流体处于快速运动中时,并且首选在靠近发动机的一个导管中时,我实现了燃烧,因此解决了以前遇到的大部分困难,并且同时显著地减少了在通过长管时会产生的辐射损失和传导损失。为了更好地确保标准工作条件的维护,我可能会在设备中添加一个由空气和蒸汽差异性操作的压力均衡器,但此设备不是必需的。调节蒸汽量,使高温混合物通过喷嘴膨胀时,达到汽轮机能安全承受的任意温度。弹性流体在穿过转子并释放出其动能的一部分后,通过排气口排出,并用于进一步预热给水、燃料,以及需要在需要时预热空气。如果强烈加热,空气和燃料将被分别输送到燃烧室,但在小型装置中,将燃料送入压缩机或空气管,同时将汽化介质引入燃烧室可能更方便。当简单是最重要的,用于可燃物和给水的廉价盘绕或加热器将被使用,但为了获得更高的热效率,我还使用了一个小型辅助锅炉,废气通过它进行循环。这样从废热中获得的蒸汽通过一个在适当压力下打开的合适的阀供给到燃烧空间中,蒸汽从那里与由蒸汽动力装置提供的蒸汽一起通过涡轮机,首先做有用功,然后加入到废热中,以上述方式被利用。更多的燃料现在可以逐渐进入以维

持正常的温度，这再次增加了排气中的热量，并导致蒸汽更快地产生，依此类推，直到最终建立稳定的状态。但是，如果在给定的运行条件下认为有利，来自主锅炉的蒸汽量可以减少，减少的量与辅助锅炉的蒸汽量大致相同。

This plan provides an efficient self-starting prime mover which may be operated as a steam - or mixed fluid turbine at will, without constructional change and is on this account very convenient. Minor departures from it, as may be dictated by the circumstances in each case, will obviously suggest themselves but if it is carried out on these general lines it will be found highly profitable to the owners of the steam plant while permitting the use of their old installation. However, the best economic results in the development of power from steam by my invention will be obtained in plants especially adapted for the purpose. It should be added that this method can also be successfully applied to condensing plants operating with high vacuum. In such a case, owing to the very great expansion ratio, the exhaust mixture will be at a relatively low temperature and suitable for admission to the condenser. Better fuel has to be used and special pumping facilities provided but the economic results attained will fully justify the increased outlay.

该方案提供了一种有效的自启动原动机，该原动机可以作为一个蒸汽涡轮机或混合流体涡轮机随意操作，而无需改变结构，因此非常方便。可能由每种情况所决定的对该方案的轻微偏离显然会建议这些偏离，但如果这些一般路线上实施该方案，将发现它对蒸汽动力装置的所有者来说是非常有利可图的，同时允许使用他们的旧设备。然而，通过我的发明从蒸汽产生动力的最佳经济效果将在特别适用于该目的的装置中获得。应该补充的是，这种方法也可以成功地应用于在高真空下运行的冷凝装置。在这种情况下，由于非常大的膨胀比，废气混合物将处于相对较低的温度，适合进入冷凝器。必须使用更好的燃料和提供特殊的泵送设备，但是所获得的经济效益将证明增加的费用是完全合理的。

Dated this 24th day of March, 1921.

日期是 1921 年 3 月 24 日。

Nikola Tesla.
尼古拉·特斯拉

COMPLETE SPECIFICATION.

完整说明

Improved Method of and Apparatus for the Economic Transformation of the Energy of Steam by Turbines.

通过涡轮机经济地转换蒸汽能量的装置的/
和改进方法

I, Nikola Tesla, Electrical and Mechanical Engineer, citizen of the United States of America, of No. 8, West 40th Street, New York, N.Y., U.S.A., do hereby declare the nature of this invention and in what manner the same is to be performed, to be particularly described and ascertained in and by the following statement:-

我、尼古拉·特斯拉、机械与电气工程师、美利坚合众国公民，居住在美国纽约市西 40 街 8 号，特此声明本发明的性质以及以何种方式执行本发明，将在下面的陈述中具体描述和确定:-

The chief object of my improvements is to increase the efficiency of existing steam power plants and thermodynamic transformers operated therefrom, but they may also be applied with like effect apart from the present establishments and are intended for the broad purpose of producing motive power, more economically, through the medium of steam mixed with the heated products of combustion, while the apparatus is capable of actuation by steam alone.

我的改进的主要目的是提高现有的蒸汽动力装置和热动力转换器的效率,但是除了现有的设施之外,它们也可以以类似的效果被应用,并且它们旨在更经济地通过与加热的燃烧产物混合的蒸汽介质,生产动力并用于广泛的目的,而该装置能够仅由蒸汽驱动。

It is well-known that notwithstanding the multiplication of hydro-electric and gas engine installations, most of the motive power is still derived from this agent, but only a relatively low fuel efficiency is secured owing to limitations inherent to the thermal process itself, as now carried out, and certain shortcomings of the present forms of apparatus. These drawbacks have been largely overcome in the method I have devised, which is very economical, readily applicable to the plants now in operation without substantial modifications in them, and is rendered particularly advantageous through the instrumentality of a turbine or rotary engine described in my British Patent No. 24,001 of 1910 and improvements I have made in its construction since that time. This machine is capable of operating satisfactorily at very high temperatures, with cheap fuel containing a large percentage of impurities, and without material impairment of efficiency as might be due to oxidation, roughening of the metal surfaces or similar deteriorating actions which seriously interfere with the working of other heat engines.

众所周知,尽管水力发电和燃气发动机装置成倍增加,但大部分动力仍然来自这种动力来源,但是由于现在进行的热处理本身固有限制以及现有形式的设备的某些缺点,只能获得相对较低的燃料效率。这些缺点已经在我设计的方法中成功地克服了,该方法非常经济,容易应用于现在正在运行的蒸汽动力装置中,而不需要对它们进行明显的修改,并且该方法通过我在 1910 年的被授予的英国专利第 24,001 号(类似美国专利第 1,061,142 号和第 1,061,206 号)中描述的涡轮机或旋转发动机的方法以及我从那时起对其结构进行的改进而变得特别有优势。这种机器能够在非常高的温度下令人满意地运行,使用廉价的燃料,燃料含有大百分比的杂质,并且没有由于氧化、金属表面粗糙化或类似的严重干扰现在使用的其他热力发动机的工作的退化行为而导致的对效率的实质性损害。

In applying my invention to a steam power plant I use air, under a pressure about equal to that of the boiler, for burning gas, crude oil, colloidal fuel or powdered coal in a chamber or conduit, the products of combustion escaping from the same mixing with the steam on their way to the turbine being thus diluted and cooled to the desired temperature. The provisions to this end will greatly vary according to

conditions. In central stations, factories, on shipboard and in many other places compressed air, as well as steam, is available and often, too, all the facilities for fuel storage and supply may be on hand. In such cases the benefits of my improvements will be readily derived with but little additional apparatus and at small cost. If the circumstances require, I provide an air-and sometimes also a gas-compressor driven either directly from the shaft of the primemover or independently by electricity, steam or other motive agent. Generally these machines will be of the more efficient reciprocating kind, but rotary compressors or composite types may be employed to secure some advantage. Irrespective of specific arrangements, I effect the combustion and mixing while the fluids are in rapid motion in a conduit which is, preferably, in close proximity to the turbine, thus disposing of most of the abovementioned difficulties previously encountered and at the same time considerably reducing the radiation and conduction losses which would be incurred in the passage through long pipes. To better insure the maintenance of standard working conditions, I may add to the equipment a device of the usual construction for equalizing the steam and air pressures. The quantity of steam is so regulated that the highly heated mixture, upon expansion through the nozzle, enters the turbine at a temperature which the machine can safely withstand. The elastic fluids, after traversing the rotor and giving up to the same a part of their kinetic energy, escape through the exhaust openings and may serve the further purpose of preheating the feedwater, fuel, and likewise the air when desired. If intensely preheated, the air and fuel will be conveyed to the combustion chamber or conduit separately, but in small installations it may be convenient to feed the fuel into the compressor or the air pipe thus bringing about a thorough mixture of the combustibles. When simplicity is of paramount importance, heaters may be resorted to for improving the economy, but in order to attain a still higher thermal efficiency I provide a boiler through which the working fluids, exhausted from the turbine, are circulated. The steam thus obtained from waste heat is fed through a suitable valve, into an inlet pipe whence it passes either separately or together with the mixed working fluid through the nozzle, first doing useful work and then adding to the waste heat of the exhaust. More fuel may now be gradually admitted to maintain in the inlet pipe the normal temperature, thus again increasing the heat in the exhaust and causing a more rapid generation of the steam, and so on, until finally a steady regime is established. However, if deemed of advantage under given operative conditions, the steam furnished by the plant may be reduced in quantity in approximately the same measure as that from the boiler is supplied.

在将我的发明应用于蒸汽动力装置时，我在大约等于锅炉压力的压力下使用空气，用于在腔室或导管中燃烧气体、原油、胶体燃料或煤粉，从与蒸汽的混合中逃逸的燃烧产物在通向涡轮机的途中被稀释和冷却到预期的温度。这方面的配备将因条件不同而有很大差异。在中心电站、工厂、船上和许多其他地方，压缩空气和蒸汽都是可用的，而且通常所有的燃料储存和供应设施都在场。在这种情况下，我的改进的好处将很容易获得，只需很少的额外设备和很小的成本。如果情况需要，我提供一个空气压缩机，必要时也提供一个燃气压缩机，直接由原动机的轴驱动或由电、蒸汽或其他动力剂独立运行。总的来说，这些机器是效率更高的往复类型，但也可以采用旋转式压缩机或复合式压缩机来保证某些优势。不考虑具体的布置，当流体在导管中快速运动时，我实现了燃烧和混合，该导管最好紧邻涡轮机，因此解决了之前遇到的大部分上述困难，并且同时显著地减少了在通过长管道时会产生辐射和传导损失。为了更好地确保标准工作条件的维护，我可以给装置添加一个通常结构的设备来平衡蒸汽压力和空气压力。蒸汽量应该被调节得使高温混合物通过喷嘴膨胀后，能以机器能够安全承受的温度进入汽轮机。弹性流体在穿过转子并释放出相同的一部分动能后，通过抽排口排出，并可用于进一步预热给水、燃料，以及在需要时预热空气。如果强烈预热，空气和燃料将被分别输送到燃烧室或管道，但在小型装置中，将燃料送入压缩机或空气管道可能比较

方便，从而使可燃物彻底混合。当简单性至关重要时，可以使用加热器来提高经济性，但为了获得更高的热效率，我提供了一个锅炉，从涡轮机排出的工作流体通过该锅炉循环。这样从废热中获得的蒸汽通过合适的阀供给到入口管中，从那里蒸汽或者单独地或者与混合的工作流体一起通过喷嘴，首先做有用功，然后添加到排气的废热中。现在可以逐渐允许更多的燃料进入，以保持进气管中的正常温度，从而再次增加排气中的热量，并导致更快速地产生蒸汽，等等，直到最终建立稳定的状态。然而，如果认为在给定的操作条件下是有利的，则蒸汽动力装置提供的蒸汽数量可以减少，减少量与从锅炉提供的量大致相同。

My invention will be more fully understood by reference to the accompanying drawings in which Figure 1 illustrates the general arrangement of the apparatus comprising the turbine, a compressor, a storage tank for the fuel, a boiler and the necessary pipe connections and controlling devices, and Figure 2 a vertical cross-section of the main valve for admission of the steam and regulation of its flow. In the first named figure, 1 represents my turbine with its shaft flexibly coupled to a machine performing useful work, as dynamo 2. The general construction of the turbine is preferably as described in my British Patent No. 24,001 of 1910, two nozzles being provided, which are intended to operate in the same direction. The nozzles are contained in two diametrically opposite enlargements of the casing and communicate with inlet pipes 3 and 4 which are joined, through suitable valves 5 and 6, to the main steam admission and control valve 7, shown in section Figure 2 and to be described in detail.

通过参考附图，将更全面地理解我的发明，在附图中：图 1 展示了设备的总体布置，该设备包括涡轮机、压缩机、燃料储罐、锅炉和必要的管道连接和控制装置；以及图 2 是用于蒸汽进入和蒸汽流量调节的主阀的垂直截面图。在第一个命名的图中，1 代表我的涡轮机，其轴柔性地连接到执行有用功的机器，如发电机 2。涡轮机的总体结构最好如我在 1910 年被授予的英国专利第 24,001 号中所描述的那样，配有两个喷嘴，它们在同一方向上工作。喷嘴被包含在壳体的两个径向相对的扩大部分中，并与入口管 3 和 4 连通，入口管 3 和 4 通过合适的阀 5 和 6 连接到主蒸汽的进入阀门和控制阀门 7，如图 2 的截面所示，并将详细描述。

The air compressor can be of any kind but is shown of the reciprocating high speed type, driven by an electric motor 8, and comprising two stages 9 and 10, with an intercooler 11. A pipe 12 carrying valve 13, connects the discharge duct of the compressor to flanged conduits 14 and 15 which are bolted to the inlet pipes 3 and 4 as indicated and equipped with means for ignition, as spark plugs 16 and 17. An extension 18 of pipe 12 leads through a valve 19, to the top of the fuel tank 20 and serves the purpose of maintaining in the latter the required pressure. When the employment of an air reservoir is deemed preferable extension 18 will be put in communication with the same through valve 21. A filling pipe 22, armed with valve 23, is attached to the top of tank 20 while near to its bottom is joined a discharge pipe 24 provided with valve 25 leading through a needle valve 26 to an automatic control valve 27 which is connected by pipes 28 and 29 to the flanged conduits 14 and 15.

空气压缩机可以是任何类型的，但所示为往复式高速型，由电动机 8 驱动，包括两级 9 和 10，带有中间冷却器 11。带有阀 13 的管道 12 将压缩机的排放导管连接到凸缘导管 14 和 15 上，凸缘导管 14 和 15 如图所示用螺栓固定到进气管 3 和 4 上，并配有点火装置，如火花塞 16 和 17。管道 12 的延伸部分 18 通过阀 19 通向燃料箱 20 的顶部，并用于保持燃料箱中所需的压力。当使用空气储存器被认为是首选的时，延伸部 18 将通过阀 21 与空气储存器连通。装备有阀 23 的注入管 22 连接到罐 20 的顶部，而靠近罐 20 底部连接有排放管 24，排放管 24 配有阀 25，通过针阀 26 通向自动控制阀 27，自动控制阀 27 通过管 28 和 29 连接到凸

缘导管 14 和 15。

The main valve 7 is designed for control of the steam flow both by automatic means and independently of the same. Its construction is clearly indicated in Figure 2, representing a vertical cross-section. The device consists of a casting 30 with inlet ports 31 and outlets 32 and 33, which are joined by flanges to pipes 3 and 4. The open bottom of the casting is connected to a steam inlet pipe 34 while the top carries a throttle valve 35 for turning on and shutting off the steam. Below the seat of this valve the casting has a transversal bore, into which is freely fitted a hollow cylinder 36 with balanced intake and exhaust openings, the latter registering with outlets 32 and 33 in the casting. The cylinder 36 is rigidly joined through a rod 37 with a hollow plunger 38 (Fig. 1) having diametrically opposite ports matching those in the stationary part of valve 27.

主阀 7 被设计用于通过自动装置和独立于自动装置来控制蒸汽流量。它的结构清楚地显示在图 2 中, 图 2 表示一个垂直截面。该装置包括一个具有入口 31 和出口 32 和 33 的铸件 30, 它们通过凸缘连接到管道 3 和 4 上。铸件的开口底部连接到蒸汽入口管 34, 而顶部带有用于打开和关闭蒸汽的节流阀 35。在该阀的阀座下方, 铸件具有一个横向钻孔, 一个带有被平衡的进气口和排气口的空心圆柱体 36 自由地装配在该孔中, 抽排口与铸件中的出口 32 和 33 对齐。缸体 36 通过杆 37 与一个中空柱塞 38 (图 1) 刚性连接, 柱塞 38 具有与阀 27 的静止部分中的端口匹配的径向相对的端口。

The boiler 39, which may be of the vertical tubular type as illustrated, is connected through its headers 40 and 41 on the lower end to main 42 communicating with the exhaust opening 43 of the turbine, and on the upper one to discharge conduit 44 through which the hot fluids, after traversing the boiler tubes, escape into the atmosphere or are led to an economizer for preheating the feed-water or otherwise utilizing the waste heat. A conduit 45 joins the top of the boiler to inlet pipe 3 through a suitable valve 46 which may be operated either by hand or automatically. From the foregoing the operation will now be readily understood. At the start valve 46 being closed and 5 and 6 open, steam from the plant is admitted through throttle and control valve 7 whence it passes into the inlet pipes 3 and 4 and communicating nozzles from which it issues at high velocity setting the rotor in motion, the machine operating purely as a steam turbine. The spark plugs 16 and 17 are then brought into play and valves 13, 19 and 25 opened, the latter allowing the fuel to flow from the tank, chiefly under the action of gravity, to needle valve 26 which is gradually turned on. The fuel thereupon passes through the ports of hollow plunger 38 and pipes 28 and 29 into apparatus for mixing and combustion, the construction of which is clearly shown in the cross-section at the lower branch, it being understood that the arrangement on the upper branch is identical. As will be seen the conduit 15 is armed on one end with a spraying device and on the other with a funnel-shaped extension which is held tight between flanges and projects far into the steam inlet pipe 4. The fuel, atomized by the intruding air, enters the combustion chamber formed by an enlargement in conduit 15, and is then ignited in the same, the products of combustion escaping into the inlet pipe 4 and mixing with the steam on their way to the nozzle. This kind of apparatus overcomes the difficulty heretofore encountered in attempts to effect combustion practically and will work satisfactorily even if there are considerable fluctuations in the steam and air pressures, as the faster moving fluid aspirates the slower one. It has been assumed that liquid fuel is used but powdered coal may also be employed in substantially the same manner with slight constructive modifications, the powder being conveyed to the combustion chamber either independently of, or with, the air. The quantity of the combustibles is so regulated by manipulation of

valves 13 and 26 (and also 5, 6 and throttle 7, if suitable) that the mixture, escaping from the nozzles, will be at a temperature considered safe for the operation of the turbine. To facilitate this any of the well-known compound valves may be provided for the purpose of admitting the combustibles always in the required proportions irrespective of their total quantity.

锅炉 39 可以是如图所示的垂直管式,其下端通过集管 40 和 41 连接到总管 42,总管 42 与汽轮机的抽排口 43 连通,其上端连接到排放导管 44,热流体在穿过锅炉管后通过排放导管 44 排放到大气中,或者被引导到节热器,以预热给水或利用废热。导管 45 通过适合的阀门 46 将锅炉的顶部连接到入口管 3,阀门 46 可以手动或自动地操作。根据前述内容,现在将容易理解该操作。当启动阀 46 关闭,5 和 6 打开时,来自蒸汽动力装置的蒸汽通过节流和控制阀 7 进入入口管 3 和 4 以及连通的喷嘴,蒸汽从这些喷嘴以高速喷出,使转子运动,机器完全作为汽轮机运行。然后,火花塞 16 和 17 开始工作,阀 13、19 和 25 打开,这些阀允许燃料主要在重力作用下从燃料箱流向逐渐打开的针阀 26。于是,燃料通过中空柱塞 38 的端口和管道 28 和 29 进入用于混合和燃烧的装置,该装置的结构清楚地显示在下方分支的横截面中,可以理解,上方分支的布置是相同的。可以看出,导管 15 的一端装备有喷射装置,另一端装备有漏斗形延伸部,该延伸部被紧固在凸缘之间,并大大伸入到蒸汽入口管 4 中。被汹涌进入的空气所雾化的燃料进入由导管 15 中的扩大部分形成的燃烧室,然后在该燃烧室中被点燃,燃烧产物逃逸到入口管 4 中,并在通向喷嘴的途中与蒸汽混合。这种装置克服了迄今为止在实际实现燃烧的尝试中遇到的困难,并且即使在蒸汽和空气压力有相当大的波动时也能令人满意地工作,因为较快运动的流体吸入较慢的流体。已经假设使用液体燃料,但是也可以以基本上相同的方式使用粉煤,只是稍微进行了结构上的修改,粉末或者独立于空气或者与空气一起被输送到燃烧室。通过操纵阀 13 和 26 (如果合适的话,还有阀 5、6 和节流阀 7) 来调节可燃物的量,使得从喷嘴逸出的混合物将处于被认为对涡轮机的运行安全的温度。为方便起见,可设置任何众所周知的复合阀,以允许可燃物始终以所需的比例进入,而不管其总量如何。

When the steam in boiler 39, raised by the exhaust mixture passing through the tubes, attains the required pressure, it is admitted through valve 46, conduit 3 and corresponding nozzle, to the rotor, adding kinetic energy to the same. Feed-water, preferably heated by the turbine exhaust, is supplied to the boiler in the same measure as steam is drawn off, any ordinary means to this end being employed.

当锅炉 39 中的蒸汽被通过管道的废气混合物升高,达到所需的压力时,蒸汽通过阀 46、导管 3 和相应的喷嘴进入转子,给转子增加动能。最好由汽轮机排气加热的给水,以与抽出蒸汽相同的方式供给锅炉,为此可采用任何普通手段。

The automatic control of the flow of steam and fuel may be effected by any kind of speed governor operatively connected to rod 37 so that the supply is reduced as the speed increases. In addition to the means shown, an air valve may be provided, actuated automatically by the governor either through rod 37 or otherwise. For further convenience and to enable the independent control of the air and fuel supply in the two branches, conduits 14, 15 and pipes 28, 29 may be equipped with valves, indicated in Fig. 1, the numbering of which is deemed unnecessary.

蒸汽和燃料的流量的自动控制可通过任何类型的调速器来实现,该调速器可通过操作连接到杆 37 上,从而当速度增加时供应量减少。除了所示的装置之外,可以设置一个空气阀,由调速器通过杆 37 或其它方式自动驱动。为了进一步方便和能够独立控制两个分支中的空气

和燃料的供应，导管 14、15 和管道 28、29 可以装备有阀，如图 1 所示，没有必要对它编号。

The amount of power obtainable from boiler 39 will vary according to conditions. Turbines as described in my said prior specification are capable of operating at a very high exhaust temperature and then the energy recovered from the waste heat in this manner may be a large fraction of the whole useful work. In such as case conduit 3, pipes 14 and 28 together with all their adjuncts, as illustrated, can be omitted and the steam supplied directly to the nozzle through valve 46. Or these connections and adjuncts may be left undisturbed and a separate nozzle provided. In admitting the steam from the boiler to the turbine rotor through independent channels, the practical advantage is secured that the pressure may vary considerably without detracting much from the efficiency of the machine, which will be improved through preheating of the combustibles by any of the well-known means.

可从锅炉 39 获得的功率量将根据条件而变化。如我所说的在先前说明书中所述的涡轮机能够在非常高的抽排温度下运行，然后以这种方式从废热中回收的能量可能是整个有用功的很大一部分。在这种情况下，如图所示，导管 3、管道 14 和 28 及其所有附件可以省略，蒸汽通过阀 46 直接供给到喷嘴。或者这些连接和附件可以保持不受干扰，并配有一个单独的喷嘴。在允许蒸汽从锅炉通过独立的通道进入涡轮机转子的过程中，实际优势是，压力可以变化很大，而不会大大降低机器的效率，利用任何众所周知的方法来预热可燃物将会提高该效率。

This plan provides an efficient self-starting mixed-fluid turbine which may also be operated with steam alone, merely by shutting off the air and fuel supply, and is on this account very convenient. Minor departures from it, as may be dictated by the circumstances, will obviously suggest themselves, but if it is carried out on these general lines it will be found highly profitable to the owners of the steam plant while permitting the use of their old installation. However, the best economic results in the development of power from steam by my invention will be obtained in plants especially adapted for the purpose. It should be added that this method can also be successfully applied to condensing plants operating with high vacuum. The production and maintenance of the latter will be materially facilitated by the employment of a pump as shown in my British patent before referred to. In such instances, owing to the very great expansion ratio, the exhaust mixture will be at a relatively low temperature and suitable for admission to the condenser. This will call for better fuel and special pumping facilities, but the economic results attained will fully justify the increased outlay.

该方案提供了一种有效的自启动混合流体涡轮机，该涡轮机也可以仅通过切断（关闭）空气和燃料供应而仅用蒸汽来操作，因此非常方便。可能由每种情况所决定的对该方案的轻微偏离显然会建议这些偏离，但如果这些一般路线上实施该方案，将发现它对蒸汽动力装置的所有者来说是非常有利可图的，同时允许使用他们的旧设备。然而，通过我的发明从蒸汽来产生动力的最佳经济效果将在特别适用于该目的的设备中获得。应该补充的是，这种方法也可以成功地应用于在高真空下运行的冷凝设备。后者的生产和维护将通过使用如我在前面提到的英国专利中所示的泵而得到极大的便利。在这种情况下，由于非常大的膨胀比，废气混合物将处于相对较低的温度，适合进入冷凝器。这将需要更好的燃料和特殊的泵送设备，但所取得的经济效益将完全证明增加支出是合理的。

Having now particularly described and ascertained the nature of my said invention and in what manner the same is to be performed, I declare that what I claim is:-

现在特别描述和确定了我的上述发明的性质和以何种方式执行，我宣布我主张的是:-

1. In a turbine installation normally working with a mixture of steam and products of combustion and in which the exhaust heat is used to provide steam which is supplied to the turbine, providing a valve governing the supply of such last mentioned steam so that the pressures and temperatures can be adjusted to the optimum conditions of working.

1、在通常以蒸汽和燃烧产物的混合物工作的涡轮机装置中，其中废热用于供给涡轮机的蒸汽，配备一个能控制这种最后提到的蒸汽供给的阀，使得压力和温度可以调节到最佳工作条件。

2. A turbine installation as described and claimed in Claim 1 so arranged that it is capable of starting with steam alone.

2、如主张要求 1 所述的涡轮机装置，其布置使得其能够仅用蒸汽启动。

3. A turbine installation as described and claimed in Claim 1 or 2 in which the turbine is of the friction disc type adapted to work with fluids at a very high temperature such as is described in Specification 24,001 of 1910.

3、如主张要求 1 或 2 所述的涡轮机装置，其中涡轮机是摩擦圆盘式的，适于在非常高的温度下依靠流体工作，如 1910 年的专利说明书 24,001 中所描述的。

4. The combined apparatus substantially as described and shown in the drawings.

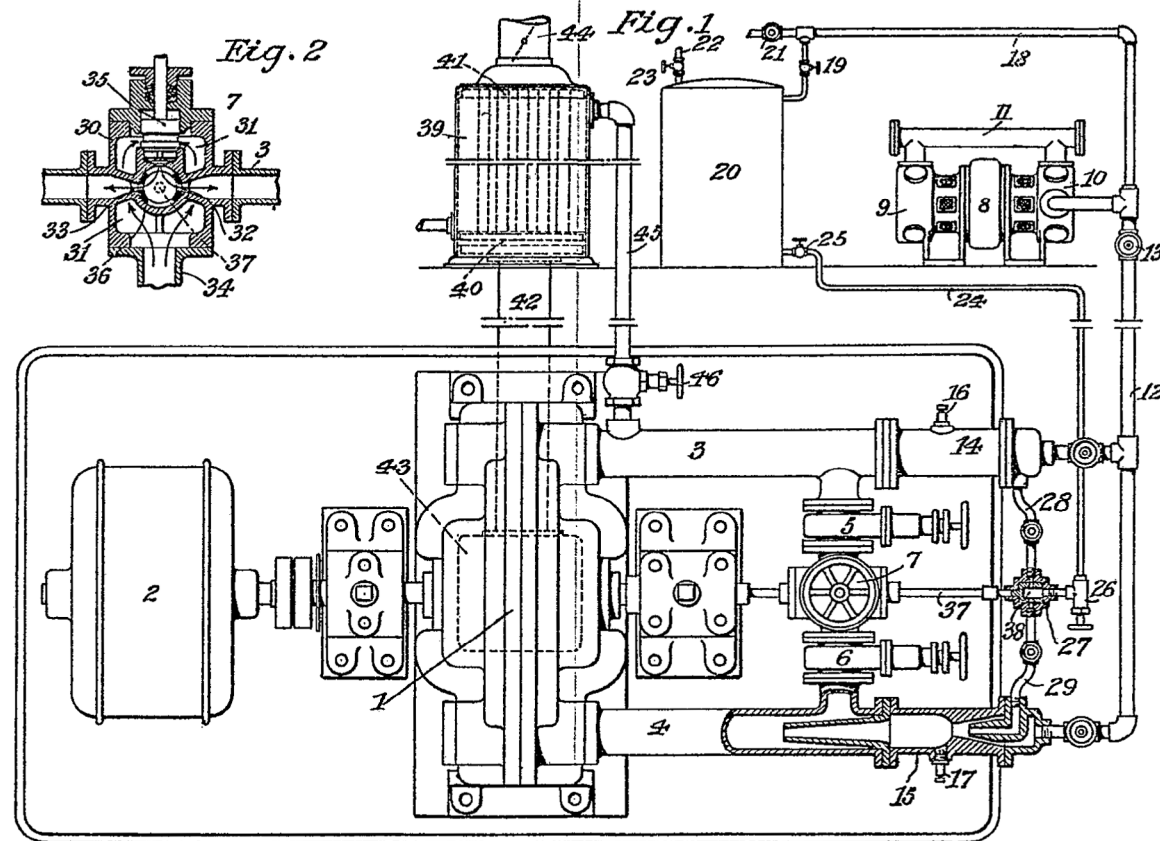
4、该组合设备基本上如附图中所描述和展示的。

Dated the 23rd day of August, 1921.

日期是 1921 年 8 月 23 日。

Nikola Tesla.
尼古拉·特斯拉

[This Drawing is a full-size reproduction of the Original]



Improved Process of and Apparatus for Deriving Motive Power from Steam

从蒸汽中获得动力的装置的/和改进方法

PATENT SPECIFICATION

186,084

专利说明书第 186,084 号

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完全接受：1922 年 9 月 25 日

PROVISIONAL SPECIFICATION.

临时说明

I, Nikola Tesla, Mechanical and Electrical Engineer, Citizen of the United States of America, of 8, West 40 Street, New York City, U.S.A., do hereby declare the nature of this invention to be as follows:

我、尼古拉·特斯拉、机械与电气工程师、美利坚合众国公民，居住在美国纽约市西 40 街 8 号，特此声明本发明的性质如下：

This improvement provides a very simple means for increasing the economy of steam turbines and is chiefly intended to be used in the operation of small units but may also be applied, with more or less success, to machines of considerable capacity, the saving effect depending largely on the conditions existing in the steam-plants where it is introduced.

这种改进为提高蒸汽涡轮机的经济性而提供了一种非常简单的方法，主要用于小型机组的运行，但也可以或多或少地成功应用于大容量的机器，其节能效果很大程度上取决于采用这种方法的蒸汽厂的条件。

The economic gain will be especially pronounced in factories and industrial establishments in which the steam pipes are long and serious loss is incurred through condensation and otherwise.

这种经济收益在工厂和工业企业中尤其显著，在这些工厂和工业企业中，蒸汽管道很长，并且由于冷凝和其它原因会产生严重的损失。

The apparatus for carrying out the process is capable of slight modifications and can be employed in conjunction with different types of turbines, but is particularly suited to that described in my British Patent No. 24,001 of 1910, in which propulsion is effected by the adhesive and viscous action of the

motive fluid. Irrespective of constructive features the general arrangement will be as follows:

用于实施该方法的装置可以稍加修改，并可以与不同类型的涡轮机结合使用，但特别适合于我在 1910 年的英国专利第 24,001 号（类似美国专利第 1,061,142 号和第 1,061,206 号）中所描述的装置，其中推进是通过运动流体的黏附性和黏滞性作用来实现的。不考虑结构特征，总体布置如下：

The steam from the boiler is led through a superheater to the turbine nozzle and the high velocity jet projected from it against the rotor creates a suction in the adjacent space which is connected to the superheater pipes or coils, thus causing a strong air current to pass through the same. The air first enters a chamber to which gas or other fuel is supplied and the products of combustion are aspirated through the coils into the turbine, superheating the steam to the desired degree, also increasing the temperature of the stream through the turbine rotor and, incidentally, imparting to it some of their kinetic energy. All of these actions co-operate in raising the efficiency of the machine with the result of bringing about an important reduction of operative expense.

来自锅炉的蒸汽通过过热炉被引导至涡轮喷嘴，从该喷嘴向转子喷射的高速射流在连接至过热器管道或盘管的邻接空间中产生吸力，从而导致强空气流穿过该管道或盘管。空气首先进入由气体或其他燃料所供给的腔室，燃烧产物通过盘管被吸入涡轮机，使蒸汽过加热到所需的程度，也增加了通过涡轮机转子的蒸汽的温度，并且顺便将它们的一些动能传递给转子。所有这些措施共同提高了机器的效率，从而大大降低了运行费用。

To improve the performance of the apparatus I employ two concentric nozzles, steam being admitted to the turbine through one and the products of combustion through the other. Furthermore, in order to turn to good use the waste heat of the exhaust I attach to the latter an economiser for preheating the feedwater and fuel, thereby effecting additional saving.

为了提高设备的性能，我采用了两个环列喷嘴，蒸汽通过一个喷嘴进入涡轮机，燃烧产物通过另一个喷嘴。此外，为了充分利用废气的废热，我在废气上安装了一个节热器，用于预热给水和燃料，从而实现额外的节约。

This invention dispenses with the compressor ordinarily required in connection with a gas turbine and will be found valuable on account of its extreme simplicity, low cost of installment and facilities it affords.

本发明摒弃了与燃气涡轮机有关的通常需要的压缩机，并且由于其极其简单、安装成本低以及所提供的便利，将会被发现它是有价值的。

Dated this 24th day of March, 1921.

日期为 1921 年 3 月 24 日。

Nikola Tesla.
尼古拉·特斯拉

COMPLETE SPECIFICATION.

完整说明

Improved Process of and Apparatus for Deriving Motive Power from Steam.

从蒸汽中获得动力的装置的/和改进方法

I, Nikola Tesla, Electrical and Mechanical Engineer, citizen of the United States of America, of 8, West 40th Street, New York, N.Y., U.S.A., do hereby declare the nature of this invention and in what manner the same is to be performed, to be particularly described and ascertained in and by the following statement:-

我、尼古拉·特斯拉、机械与电气工程师、美利坚合众国公民，居住在美国纽约市西 40 街 8 号，特此声明本发明的性质以及以何种方式执行本发明，将在下面的陈述中具体描述和确定:-

This improvement provides a very simple means for increasing the economy of steam turbines and is chiefly intended to be used in the operation of small units but may also be applied, with more or less success, to machines of considerable capacity, the saving effect depending hugely on the conditions existing in the steam-plants where it is introduced. The economic gain will be especially pronounced in factories and industrial establishments in which the steam pipes are long and serious loss is incurred through condensation and otherwise. The apparatus for carrying out the process is capable of slight modifications and can be employed in conjunction with different types of turbines, but is particularly suited to that described in my British Patent No. 24,001 of 1910, in which propulsion is effected by the adhesive and viscous action of the motive fluid. Irrespective of constructive features the operation will be generally as follows:

这种改进为提高蒸汽涡轮机的经济性提供了一种非常简单的方法，主要用于小型机组的运行，但也可以或多或少地成功应用于具有相当大容量的机器，节约效果在很大程度上取决于引入它的蒸汽工厂的现有条件。这种经济收益在工厂和工业企业中尤其显著，在这些工厂和工业企业中，蒸汽管道很长，并且由于冷凝和其它原因会产生严重的损失。用于实施该方法的装置可以稍加修改，并可以与不同类型的涡轮机结合使用，但特别适合于我在 1910 年的英国专利第 24,001 号（类似美国专利第 1,061,142 号和第 1,061,206 号）中所描述的装置，其中推进是通过运动流体的黏附性和黏滞性作用来实现的。不考虑结构特征，操作通常如下：

The steam from the boiler is led to the nozzle through a superheater, which should be placed as near as possible to the turbine, and the high velocity jet, projected from it against the rotor, creates a suction in the adjacent space which is connected to the superheater pipes or coils, thus causing a strong air current to pass through the same. The air first enters a combustion chamber to which gas or other fuel is supplied and the products are aspirated through the coils into the turbine, superheating the steam to the desired degree, also increasing the temperature of the stream through the turbine rotor and, incidentally, imparting to it some of their kinetic energy. All of these actions co-operate in raising the

efficiency of the machine with the result of bringing about an important reduction of operative expense.

来自锅炉的蒸汽通过过热炉被引导至喷嘴，该过热炉应尽可能靠近涡轮机放置，从过热器向转子喷射的高速射流在连接至过热器管道或盘管的邻接空间中产生吸力，从而导致强大的空气流通过这些管道或盘管。空气首先进入一个燃烧室，燃气或其他燃料也被供应到该燃烧室，燃烧产物通过盘管被吸入涡轮机，将蒸汽过加热到预期的程度，还增加了通过涡轮机转子的蒸汽的温度，并且顺便将它们的一些动能传递给它。所有这些措施共同提高了机器的效率，从而大大降低了运行费用。

To improve the performance of the apparatus, I preferably employ two concentric non-convergent nozzles, steam being admitted to the turbine through one and the products of combustion through the other. Furthermore, in order to turn to good use the waste heat of the exhaust I may attach to the latter an economiser for preheating the feed-water and fuel, thereby effecting additional saving.

为了提高设备的性能，我优选使用两个环列式非收敛喷嘴，蒸汽通过一个喷嘴进入涡轮机，燃烧产物通过另一个喷嘴。此外，为了充分利用废气的废热，我可以在废气上安装一个节热器，用于预热给水和燃料，从而实现额外的节约。

The preferred form of apparatus for carrying out the process above described is illustrated in the accompanying drawings in which Fig. 1 is a side view in elevation, partly cross-sectioned, and Fig. 2 a vertical section through one of the parts for supplying steam and combustion products to the turbine.

用于实施上述方法的装置的优选形式在附图中示出，其中图 1 是局部截面的侧视图，图 2 是穿过用于向涡轮机供应蒸汽和燃烧产物的部件之一的垂直截面图。

Referring to the figures more specifically, 1 is the rotor and 2, 2 the enclosing casing of the turbine which is provided with two diametrically opposite enlargements 3, 3 bored out and fitted with concentric conduits 4, 4 and 5, 5 for supplying the working fluids to the rotor. These are equipped with, or form part of, corresponding discharge nozzles 6, 6 and 7, 7. The superheater consists of a steam-chamber 8 closed at the ends by plates 9 and 10 and containing a coiled pipe 11, the ends of which are led out, one being connected to a combustion chamber 12 and the other to an outlet pipe 13 with branches 14 and 15 leading to the inner supply channels 16, 16. Steam inlet and outlet pipes, respectively, 17 and 18, are provided, the latter with two branches 19 and 20 communicating with channels 21, 21 of the supply part. Suitable steam, air and gas inlet valves, respectively marked 22, 23 and 24 may be employed for controlling and regulating the supply of the working fluids to the turbine. All the supply channels should be of a section sufficiently large so that the velocities of the fluids through them will be small as compared with those attained in the nozzles.

更具体地参照附图，1 是转子，2、2 是涡轮机的封闭壳体，该壳体配备有两个径向相对的扩大部 3、3，这两个扩大部被钻孔并装配有用于向转子供应工作流体的同心导管 4、4 和 5、5。它们配备有相应的排放喷嘴 6、6 和 7、7，或者形成相应排放喷嘴 6、6 和 7、7 的一部分。过热器由一个蒸汽室 8 组成，蒸汽室 8 的端部由板 9 和 10 封闭，并且蒸汽室 8 容纳一个盘管 11，盘管 11 的端部被引出，一端连接到燃烧室 12，另一端连接到出口管 13，出口管 13 具有通向内部供应通道 16、16 的分支 14 和 15。分别提供了蒸汽入口和出口管 17 和 18，后者具有与供应部件的通道 21、21 连通的两个分支 19 和 20。分别标记为 22、23 和 24 的适

合的蒸汽、空气和燃气的入口阀可用于控制和调节工作流体向涡轮机的供应。所有供应通道的截面应该足够大，使得通过它们的流体速度与在喷嘴中获得的速度相比较小。

The operation will now be readily understood. Valves 23 and 24 being closed, the steam admitted by valve 22 passes through inlet pipe 17, chamber 8, outlet 18, branches 19 and 20, spaces 21, 21 and nozzles 6, 6, setting the turbine rotor in motion thus operating the machine as a simple steam turbine subject to the usual limitations in economic performance. The inlet valve 23 is now opened permitting the atmospheric air to be drawn in through coil 11, pipe 13, branches 14 and 15, channels 16, 16 and nozzles 7, 7 to the rotor. Power gas or other fuel is then admitted through valve 24 and upon being ignited in the combustion chamber 12 the products pass through in like manner, assisted by their initial velocity. As a result of this action, coiled pipe 11 is heated to a high temperature and superheats the steam in chamber 8 and also in the supply channels and nozzles, thus adding very materially to the available energy of the steam, at the same time increasing the efficiency of thermodynamic transformation. The products of combustion themselves, impinging against the rotor, contribute usefully some of their kinetic energy. The economic gain effected in this simple manner will be all the more pronounced the poorer the initial quality of the steam and the higher the pressure supply. However, low-pressure steam, as that exhausted from turbines or reciprocating engines, may likewise be economically utilized by this process and means, especially if provision is made for maintaining a vacuum at the exhaust end of the turbine.

现在将容易理解该操作。当阀 23 和 24 关闭时，由阀 22 引入的蒸汽通过入口管 17、室 8、出口 18、支管 19 和 20、空间 21、21 和喷嘴 6、6，使涡轮机转子运动，从而使机器作为一个简单的汽轮机运行，在经济性能方面受到通常的限制。入口阀 23 现在打开，允许大气空气通过盘管 11、管道 13、支管 14 和 15、通道 16、16 和喷嘴 7、7 被吸入转子。动力气体或其他燃料然后通过阀 24 进入，并且在燃烧室 12 中被点燃后，产物借助于它们的初始速度以类似的方式通过。由于这种作用，盘管 11 被加热到一个高温，并过加热在室 8 中的以及供应通道和喷嘴中的蒸汽，从而极大地增加了蒸汽的可用能量，同时提高了热力学转换的效率。碰撞转子的燃烧产物本身提供了一些有用的动能。蒸汽的初始品质越差，供给的压力越高，以这种简单方式实现的经济效益就越显著。然而，低压蒸汽，如从涡轮机或往复式发动机抽排的蒸汽，同样可以通过这种方法和装置经济地利用，特别是利用供给在涡轮机的抽排端保持真空。

The apparatus described is capable of minor modifications. For instance, the combustibles may be admitted to the rotor through the outer channels and steam through the inner ones. Again, the nozzles instead of being co-axial, as shown, may be otherwise constructed and disposed, or single nozzles may be used in their place and the mixture of the steam and gases effected before admission to them. However, this can be more or less completely accomplished with co-axial nozzles, as illustrated, merely by shortening one of them. As to the superheater it may be of widely varied design and incorporated with the turbine casing for the purpose of saving energy, weight and space. Departures may also be made in the design of the combustion chamber to suit the fuel employed and the necessary adjuncts for carburation and ignition will be provided, all of which, being well-known, are omitted from the drawing for the sake of clearness. Obviously, the process can be applied with more or less success in the transformation of the heat energy of elastic fluids other than steam.

所描述的装置可以稍加修改。例如，可燃物可通过外部通道进入转子，蒸汽可通过内部通道

进入转子。同样，如图所示，喷嘴不是同轴的，而是可以以其它方式构造和布置，或者可以在它们的位置使用单个喷嘴，并且蒸汽和气体在进入它们之前实现混合。然而，如图所示，仅通过缩短其中一个喷嘴，这可以或多或少地用同轴喷嘴完全实现。至于过热炉，它可以有各种各样的设计，并与涡轮机壳体相结合，以节省能量、重量和空间。燃烧室的设计也可以有所变化，以适应所使用的燃料，并且将配备用于汽化和点火的必要附件，所有这些都是众所周知的，为了清楚起见，都从图中省略了。显然，这个工艺流程可以或多或少地成功应用于除蒸汽以外的弹性流体的热能转换。

This invention provides a self-starting, compact and efficient mixed-fluid turbine and will be found valuable on account of its extreme simplicity, low cost of instalment and the facilities it affords.

本发明提供了一种自启动的、紧凑的和高效的混合流体涡轮机，并且由于它极其简单、安装成本低以及它提供的便利，它将被发现是有价值的。

Having now particularly described and ascertained the nature of my said invention and in what manner the same is to be performed, I declare that what I claim is:-

现在特别描述和确定了我的上述发明的性质和以何种方式执行，我宣布我主张的是:-

1. The hereinbefore described process of thermo-dynamic transformation of energy which consists in admitting steam to a turbine nozzle, aspirating by the suction thus created hot products of combustion through a heater, superheating the steam by them and discharging them at high velocity and in a direction parallel to the steam-jet upon the rotor, as described.

1、上文所述的热动力能量转换过程，包括允许蒸汽进入涡轮喷嘴；通过加热器抽吸由此产生的热燃烧产物；通过它们使蒸汽过热，并在平行于转子上的蒸汽射流的方向上高速排出它们，如上所述。

2. The process of increasing the efficiency of steam as motive agent which consists in admitting it through a heater to a turbine nozzle, aspirating by the suction thus created hot products of combustion through the heater thereby raising the temperature of the steam to a high degree and discharging the products at high velocity and in contact with the steam-jet upon the rotor, as described.

2、提高蒸汽作为动力机制的效率的过程，包括允许蒸汽通过一个加热器进入涡轮喷嘴；通过加热器抽吸由此产生的热燃烧产物，从而将蒸汽的温度升高到很高的程度，并以高速排出产物，并与转子上的蒸汽射流接触，如上所述。

3. The method of operating a mixed fluid turbine which consists in starting it by steam admitted to the nozzle, aspirating by the suction produced in the space adjacent to the same hot products of combustion, superheating the steam by them and directing them upon the rotor so as to assist in driving it, as described.

3、操作混合流体涡轮机的方法，包括利用进入喷嘴的蒸汽来启动涡轮机；通过在邻近相同的热燃烧产物的空间中产生的吸力进行吸气，通过它们使蒸汽过热，并且将它们引导到转子上，从而帮助驱动转子，如上所述。

4. The herein described process and apparatus by which a turbine rotor is started by steam and combustible fluids are aspirated by the suction of the steam-jet into a combustion chamber, the products of combustion serving to superheat the steam and then assist in driving the rotor.

4、在此描述的方法和设备，通过该方法和设备，涡轮机转子由蒸汽起动，并且可燃流体通过蒸汽射流的抽吸被吸入燃烧室，燃烧产物用于过加热蒸汽，然后帮助驱动转子。

5. In the process described and claimed in Claims 1, 2 and 3, the use of a friction turbine of very small windage.

5、在主张要求 1、2 和 3 中所主张的和所描述的工艺流程中，使用非常小风阻的摩擦涡轮机。

6. In the process and apparatus described and claimed in Claim 4, the use of concentric non-convergent nozzles opening directly into the rotor chamber of the turbine.

6、在主张要求 4 中描述和要求的工艺流程和装置中，使用直接通向涡轮机转子室的环列式非收敛喷嘴。

7. In a mixed fluid turbine in which a secondary fluid is aspirated by the suction of the primary, the employment of non-convergent co-axial nozzles for discharging the fluids in parallel contacting streams upon the rotor, as described.

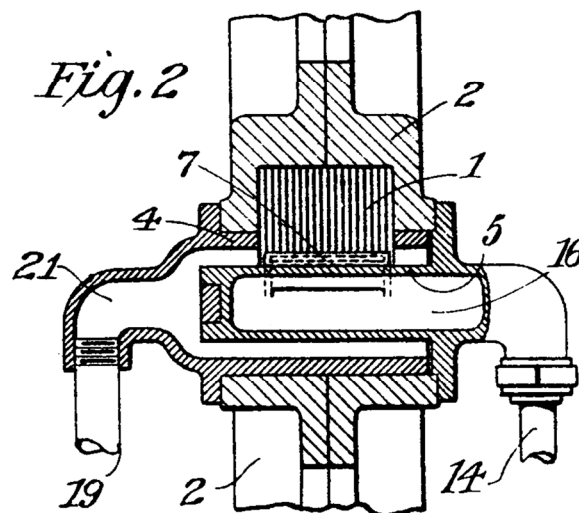
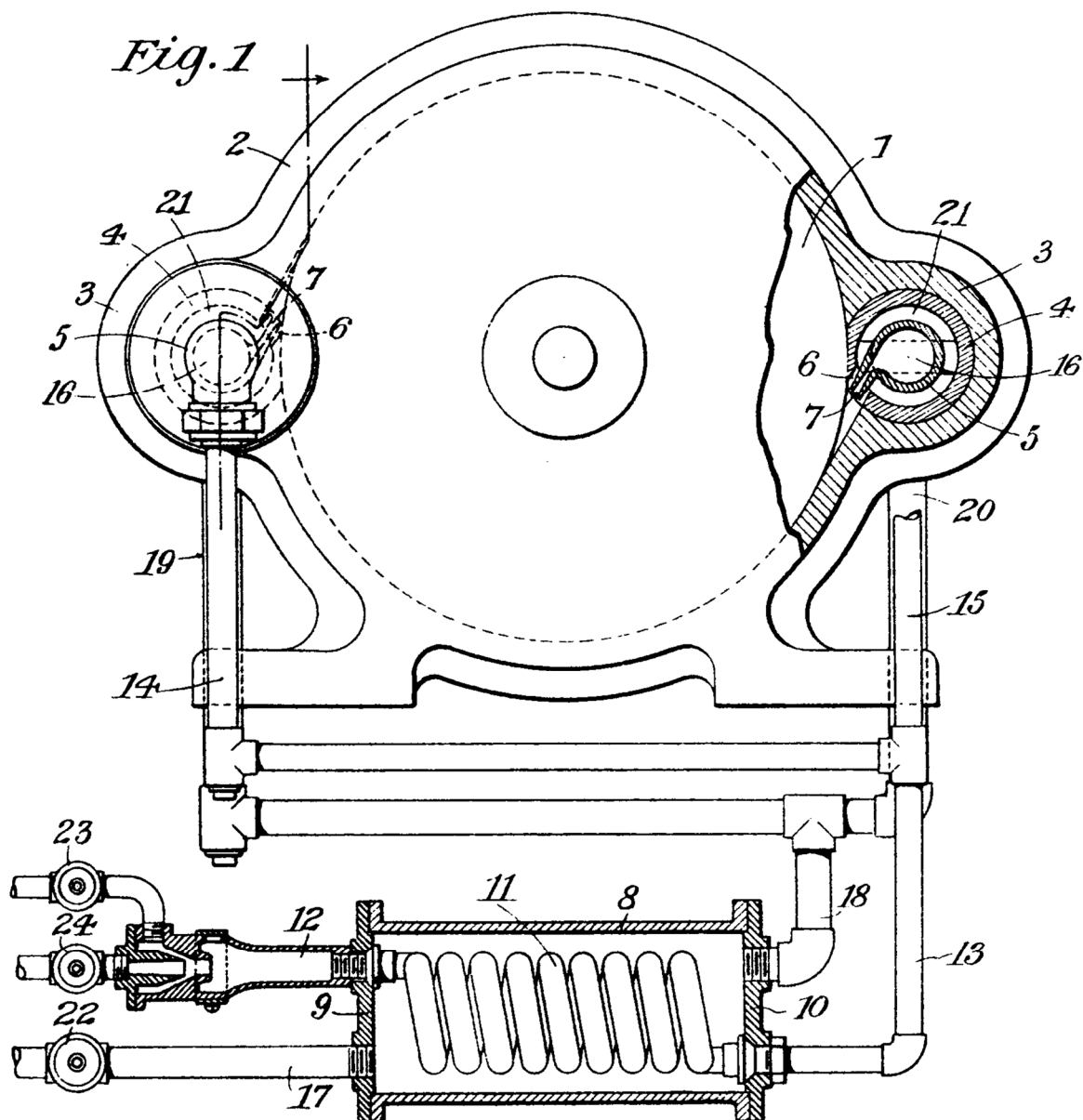
7、在一个混合流体涡轮机中，次级流体通过初级流体的吸力被吸入，采用非收敛共轴喷嘴以平行于接触流的形式将流体排放到转子上。

Dated the 23rd day of August, 1921.

日期是 1921 年 8 月 23 日。

Nikola Tesla.
尼古拉·特斯拉

[This Drawing is a reproduction of the Original on a reduced scale]



Process of and Apparatus for Balancing Rotating Machine Parts 用于平衡旋转机械部件的装置 的/和工艺流程

PATENT SPECIFICATION

186,799

专利说明书第 186,799 号

Application Date: Sept 2, 1921. No. 23,336/21.

Complete Accepted: Oct. 12, 1922.

申请日期：1921 年 9 月 2 日。编号 23,336/21。

完全接受：1922 年 10 月 2 日

COMPLETE SPECIFICATION.

完整说明

I, Nikola Tesla, Electrical and Mechanical Engineer, citizen of the United States of America, of No. 8, West 40th Street, New York, N.Y., U.S.A., do hereby declare the nature of this invention and in what manner the same is to be performed, to be particularly described and ascertained in and by the following statement:-

我、尼古拉·特斯拉、机械与电气工程师、美利坚合众国公民，居住在美国纽约市西 40 街 8 号，特此声明本发明的性质以及以何种方式执行本发明，将在下面的陈述中具体描述和确定：

In the operation of machinery the accurate balancing of the rotating parts is of great economic importance as vast sums of money are annually expended on account of deficiencies in this respect resulting in loss of power, undue wear and tear, interruption of service and accidents of a more or less serious nature.

在机械运行中，旋转部件的精确平衡具有很大的经济重要性，因为这方面的会导致动力丧失、过度磨损、服务中断以及或多或少严重事故的严重缺陷，每年都要消耗大量的资金。

Prior to the development of modern high speed apparatus static balancing was depended upon entirely and even now this is frequently the case. The steadily increasing tendency in the direction of high speed brought on the necessity of dynamic balancing and various forms of apparatus for this purpose were devised.

在现代高速仪器发展之前，完全依赖静态平衡，甚至现在也经常如此。朝着高速方向的稳定

增长趋势带来了动态平衡的必要性，并为此目的设计了各种形式的装置。

The process I have invented enables this to be done quickly and with a high degree of accuracy and, briefly stated, consists in rotating the body to be balanced, yieldably supported, at a suitable speed and removing excess material from its heavier side by abrasion, until the desired degree of perfection of balance is attained.

我发明的方法能够快速且高度精确地完成，简单地说，包括以合适的速度旋转待平衡的、被可缩性地支撑的物体，并通过磨损从其较重的一侧去除多余的材料，直到获得理想的完美平衡程度。

As means to this end I may employ a grinding wheel, a sand-blast or jet of other abrasive substance. It might be naturally inferred that the contact of an emery or carborundum wheel with a rapidly whirling machine part would be productive of dangerous shocks and vibrations, and also that grinding at speeds much higher than the usual could now be satisfactorily accomplished. But although these theoretical assumptions appear sound, I have encountered no difficulties of this kind and have performed the operation with the greatest facility and success. This I attribute to the inertia and momentum of the spinning body which makes it insensitive to such asynchronous disturbances as the wheel might produce. However, in certain cases it may be more convenient or preferable to effect the removal of the excess material by a high velocity jet of abrasive substance applied tangentially to the part to be balanced. In order to attain the best results it is essential that the latter, when rotated, shall be capable of an appreciable displacement of its center of gravity from the axis of symmetry. This is accomplished by supporting it on a shaft of suitable flexibility or, if its own shaft is not sufficiently flexible, in bearings yieldably mounted. It is furthermore of great importance, in order to avoid vibrations which would interfere with the proper application of the process, that the speed at which the grinding is effected should bear a definite relation to the critical, corresponding to the fundamental natural vibration, and the following rule should be observed: If the system is run in two bearings the grinding speed should be an odd multiple or submultiple of the critical. If, on the other hand, the system is supported on one side only, the speed should be an even multiple or submultiple of the critical.

为此，我可以使用砂轮、喷砂或喷射其他磨削物质。可以很自然地推断出，金刚砂或金刚砂砂轮与快速旋转的机器配件的接触会产生危险的冲击和振动，并且现在可以令人满意地完成比通常速度高得多的磨削。但是，尽管这些理论假设似乎是合理的，我没有遇到这类困难，并以最大的便利和成功完成了操作。我把这归因于旋转物体的惯性和动量，这使它对轮子可能产生的这种异步扰动不敏感。然而，在某些情况下，通过与待平衡部件相切的高速磨料射流来去除多余的材料会更方便或更可取。为了达到最好的效果，当旋转时，待平衡部件的重心必须能够从对称轴有明显的位移。这是通过将它支撑在具有适当柔性的轴上来实现的，或者，如果它自己的轴不够柔性，则支撑在被可缩地安装的轴承中。此外，非常重要的一点是，为了避免产生会干扰该工艺流程的正确应用的振动，进行磨削的速度应该与临界速度具有确定的关系，对应于基本的固有振动，并且应该遵守以下规则：如果系统在两个轴承中运行，磨削速度应该是临界速度的奇数倍或奇约数倍，另一方面，如果系统只在一侧被支撑，速度应该是临界速度的偶数倍或偶约数倍。

When the structure is revolving at the proper speed I bring the abrasive wheel into operative contact with it at a peripheral or other suitable region and grind off material. As the action continues, the flexure

of the shaft diminishes until, finally, its center of symmetry coincides with the center of gravity of the system, or nearly so. This can be noted in many cases by a competent operator without the use of a special device, but suitable visible or audible means may be employed for the purpose.

当该结构以适当的速度旋转时，我使用砂轮在外周或其它合适的区域与它有效接触，并磨掉材料。随着动作的继续，轴的弯曲减小，直到最后，轴的对称中心与系统的重心重合，或接近重合。在许多情况下，有能力的操作者可以在不使用特殊设备的情况下注意到这一点，但是可以为此目的使用合适的视觉装置或听觉装置。

Preliminary to the application of the process it is advisable to run the part at a very low speed and true it with the wheel. If there exists appreciable flexure of the shaft when the system rests horizontally, the grinding may be done in a vertical position when it is in static balance. A part to be run on a stiff shaft may be mounted on another of suitable flexibility; and as there exist limitations in the accuracy of fitting a cylindrical sleeve, I may employ a tapering one to secure greater precision. However, satisfactory results can generally be obtained in arming the rigid shaft with flexible extensions or holding it in bearings yieldably supported. In all cases it is desirable to flood the latter with lubricant of considerable viscosity. When balancing parts to be run at a high temperature they may be inclosed in a casing in which approximately the same temperature is maintained, an opening being provided for the introduction of the abrasive wheel or jet.

在应用该工艺流程之前，建议以非常低的速度运行部件，并用砂轮进行校正。如果当系统水平放置时，轴存在明显的弯曲，则当系统处于静态平衡时，可以在垂直位置完成磨削。在一个刚性轴上运行的一个部件可以安装在另一个合适的柔性轴上；由于安装圆柱形套筒的精度存在限制，我可以采用锥形套筒来确保更高的精度。然而，在刚性轴上安装柔性延伸件或将其保持在可被弯曲支撑的轴承中，通常可以获得令人满意的结果。在所有情况下，都最好用黏度相当大的润滑剂充满轴承。当要在高温下运行平衡部件时，它们可以被封闭在外壳中，外壳内维持大致相同温度的，并提供开口用于引入砂轮或射流。

My invention will be clearly understood by reference to the accompanying drawings illustrating a form of apparatus I have devised for the quick and convenient balancing of such bodies as rotors of my steam and gas turbines. Fig. 1 shows the general arrangement of the component parts comprising, a casing with an opening on one side, lathe mechanism for feeding the wheel, a tachometer enabling instantaneous readings of the speed to be taken, an instrument for continuous visual indication of the degree of accuracy obtained and a preheater of the elastic medium such as compressed air used in the operation; Fig. 2 represents a section through the casing in the plane of a rotor disc, exposing the said opening and also the turbine nozzle; Fig. 3 is a view of the essential parts of the balance-indicating instrument and, Fig. 4 illustrates the manner in which a jet of abrasive substance is applied when carrying out my process.

通过参考附图，将会清楚地理解我的发明，所述附图展示了我已经设计的装置的一种形式，用于快速和方便地平衡这些物体，如我的蒸汽涡轮机和燃气涡轮机的转子。图1展示了组成部件的总体布置，包括：在一侧具有一个开口的外壳、用于进给轮子的车床车削机械装置、能够获得速度的瞬时读数的转速计、用于对所获得的准确度进行连续视觉指示的仪器以及弹性介质（如运行中用到空气）的预热器；图2代表穿过转子圆盘平面中的壳体的截面图，暴露了所述的开口以及涡轮喷嘴；图3是平衡指示仪器的主要部分的视图，图4展示了在执行

我的工艺流程的过程时应用磨料射流的方式。

Calling attention specifically to the figure first named 1 is a casing, enclosing an air- or steam-driven rotor to be balanced, and shown as open at 2 for the purpose of permitting the wheel 3 to be brought into operative contact with the surfaces to be ground. Any suitable drive may be employed but I ordinarily resort to the electric, mounting the wheel directly on the shaft of a motor 4 fixed to a lathe carriage 5 which slides on rails 6, 6 and is provided with means 7 and 8 for feeding the wheel, respectively, along the axis of the motor shaft and at right angles to the same.

请特别注意图中，命名为 1 的部分是一个外壳，该外壳包围着一个要被平衡的空气驱动或蒸汽驱动的转子，并且在 2 处显示为打开的，目的是允许轮子 3 与要被研磨的表面进行操作性接触。可以采用任何合适的驱动装置，但我通常采用电驱动装置，将轮直接安装在电动机 4 的轴上，该电动机被固定在车床支架 5 上，该车床支架在轨道 6、6 上滑动，并配有用于进给轮的装置 7 和 8，7 沿着电机轴的轴线，8 与该轴线直角。

As shown in Fig. 2 the casing is split horizontally on the centerline in two castings 9 and 10, carefully planed so as to insure their coming into the same position whenever put together, lateral displacement being prevented by dowel-pins 11, 11 (Fig. 1) which are driven tight either in casting 9 or 10. These are enlarged and bored out on one side and into the hole is snugly fitted a hollow cylinder 13 with nozzle 14 and intake opening 15 directly connected to the supply pipe 16 provided with a suitable control valve. The opening at 2 for the entrance of wheel 3 is shown as a simple opening through the casing, but in certain cases I introduce the wheel through an enlargement of the casing similar to the enlargement shown in Fig. 2 on the right side, which is often convenient when balancing a rotor in its own casing.

如图 2 所示，外壳在两个铸件 9 和 10 中的中心线上水平分开，仔细刨平以确保它们在放在一起时进入同一位置，通过在铸件 9 或 10 中拧紧的定位销 11（图 1），它是用来防止横向位移。铸件 9 和 10 在一侧被扩大和钻孔，钻入紧密贴合中空圆柱体 13 的孔中，该中空圆柱体 13 具有喷嘴 14 和入口 15，该入口 15 直接连接到配有合适控制阀的供应管 16。用于轮 3 入口的 2 处的开口显示为穿过外壳的简单开口，但是在某些情况下，我通过壳体的扩大部分引入轮子，该扩大部分类似于图 2 右侧所示的扩大部分，这在平衡其自身壳体中的转子时通常是方便的。

Referring again to Fig. 1 the bearings 17 and 18 are also divided horizontally in the plane of the casing joint and their upper and lower parts may be integral with the corresponding castings 9 and 10 for the purpose of saving labor and time. The lower parts of the bearings are equipped with oil supply and discharge pipes 19 and 20. The supply pipe 16 is shown as connected to a coil 21 of a heater 22 which is equipped with a valve for controlling the flow of the heating medium and may be of any known construction. A worm drive 23 is provided on one end of the rotor shaft for operating the tachometer 24 through a flexible connection. This device may be of any make but I find it advantageous to use the air friction type. On the other end of the shaft is mounted the balance indicator 25 (shown in detail Fig. 3) consisting of a member 26 with a pointer 27 on the top and an adjustably mounted weight 28 on the bottom. This member is supported on the outer race 29 of a ball-bearing 30, the inner one 31 being fixed to the shaft, and is thus capable of oscillation, the rotary effort necessary to produce a given deflection of the same being determined by the position of the weight. A graduated scale 32 is attached to the stationary part of the instrument which is placed conveniently for observation by the operator.

再次参照图 1，轴承 17 和 18 也在套管接头的平面内水平分开，并且为了节省劳力和时间，它们的上部和下部可以与相应的铸件 9 和 10 形成整体。轴承的下部装备有供油管和排油管 19 和 20。供应管 16 显示为连接到加热器 22 的盘管 21，加热器 22 配备有用于控制加热介质流量的阀，并且可以是任何已知的结构。蜗杆驱动器 23 被设置在转子轴的一端，用于通过柔性连接操作转速计 24。这种装置可以是任何型号的，但我发现使用空气摩擦型的更有利。在轴的另一端安装有平衡指示器 25（图 3 中详细展示），该指示器由顶部带有指针 27 的部件 26 和安装在底部的可调节的重物 28 组成。该构件被支撑在滚珠轴承 30 的轴承外圈 29 上，内圈 31 被固定到轴上，因此能够摆动，用来产生该构件的给定偏转所需的旋转力由重物的位置决定。一个刻度尺 32 连接在仪器的静止部件上，便于操作者观察。

Substantially the same apparatus, with the exception of wheel 3, may be employed in connection with the device diagrammatically illustrated in Fig. 4, in which a suitable fixture 32 projects a jet 33 of abrasive substance tangentially upon the body 34 to be balanced which is supported on a flexible shaft 35. In this case of course the fixture is mounted on carriage 5 to enable feeding in two directions.

除了轮 3 之外，基本上相同的设备可以与图 4 中示意性展示的装置结合使用，其中合适的固定装置 32 将研磨物质的射流 33 切向地喷射到待平衡的主体 34 上，该主体被支撑在柔性轴 35 上。当然，在这种情况下，固定装置被安装在托架 5 上，以便能够在两个方向上进给。

The balancing is done as follows: The rotor being in position for grinding the casting 9 and covers of bearings 17 and 18 are put in place, lubricant forced through pipes 19 and 20 and a motive fluid as compressed air, admitted to nozzle 14, its quantity and temperature being regulated, respectively, by valves on supply pipe 16 and heater 22. The fluid, in traversing the rotor and exhausting through the lower casing imparts motion to the former and brings it up to the desired speed, ascertained by reading of tachometer 24. The abrasive wheel 3 is now fed across the rotor and the indication of the balancing instrument on the graduated scale noted. At the start the deflection of the pointer is likely to be considerable due to the fact that any, however slight vibration of the shaft, increases greatly the pressure on the balls and consequently the torque of the instrument. As the balance improves the deflection diminishes until finally the pointer reaches the zero of the scale indicating that the desired degree of perfection of balance has been attained. As a crucial test the operator may then run the rotor at about the critical speed. This should cause no appreciable vibration or effect on the balance indicator which, instead of carrying a weight, may be equipped with a spring for producing the required pressure on the ball-bearing and opposing the torsion.

平衡过程如下：转子就位用来研磨铸件 9，并且轴承盖 17 和 18 被放置到位，润滑剂被强制通过管道 19 和 20，运动流体（如压缩空气）进入喷嘴 14，其数量和温度分别由供应管道 16 和加热器 22 上的阀来调节。流体穿过转子并通过下壳体排出，使转子运动，并使其达到预期的速度，该速度由转速计 24 的读数确定。现在砂轮 3 穿过转子被送入，平衡仪器在刻度表上的指示被记录。开始时，指针的偏转可能相当大，因为轴的任何轻微振动都会大大增加球体上的压力，从而增加仪器的扭矩。随着平衡的改善，偏差逐渐减小，直到指针到达刻度的零点，表明平衡达到了理想的完美程度。作为一个关键的测试，操作者可以使转子接近临界速度运行。这应该不会对平衡指示器造成明显的振动或影响，平衡指示器可以不承载重量，而是配备一个弹簧，用于在滚珠轴承上产生所需的压力，并阻抗扭矩。

When bodies not adapted for rotation in the manner shown are to be balanced, they will be driven

independently by belt, electricity or other means, care being taken that no disturbing vibration from them is transmitted to the apparatus. In order to preserve intact the peripheral boundary, if this is essential, I grind the material off from some other place and when desirable, I make a special provision to this end in the design and construction of the part.

当不适合以所示方式旋转被平衡的物体时，它们将由皮带、电力或其他装置独立驱动，注意不要将来自它们的干扰振动传递到设备。为了保持完整的外围边界，如果这是必要的，我会从其他地方磨掉材料，当需要时，我在部件的设计和构造中为此做了特殊的规定。

I have found my process very valuable in the balancing of high-speed steam and gas turbine rotors but I have used it successfully in a great variety of cases and do not limit its application to any kind of apparatus.

我发现我的方法在高速蒸汽涡轮机和燃气涡轮机的转子的平衡中非常有价值，但是我已经在各种情况下成功地使用了它，并且不限制它在任何种类的设备中的应用。

Having now particularly described and ascertained the nature of my said invention and in what manner the same is to be performed, I declare that what I claim is:-

现在特别描述和确定了我的上述发明的性质和以何种方式执行，我宣布我主张的是:-

1. The method of balancing a body which consists in rotating it on a flexible shaft or on yieldable supports and removing excess material from it by abrasion until balance is attained, substantially as described.

1、平衡一个物体的方法，包括在一根软轴或可弯曲的支撑物上旋转该物体，并通过磨削掉多余的物质，直达到平衡，基本上如所述。

2. The process of balancing a body which consists in rotating it under normal working conditions, on a suitable flexible shaft, and causing it to balance by grinding off excess material from it, substantially as described.

2、平衡物体的流程，包括在正常工作条件下，在合适的软轴上旋转该物体，并通过磨削掉物体上多余的材料使其达到平衡，基本上如所述。

3. The process of balancing a body which consists in rotating it on a suitable flexible shaft supported on two bearings, at a speed which is an odd multiple or submultiple of the critical and grinding off excess material therefrom, substantially as described.

3、平衡物体的流程，包括使物体以临界速度的奇数倍或奇约数倍的速度在由两个轴承支撑的合适的柔性轴上旋转，并磨削掉多余的材料，基本上如所述。

4. The process of balancing a body which consists in rotating it on a suitable flexible shaft supported on one side only, at a speed which is an even multiple or submultiple of the critical and grinding off excess material therefrom, substantially as described.

4、平衡一个物体的流程，包括以临界转速的偶数倍或偶约数倍的速度，在一个只在一侧支撑的合适的柔性轴上旋转该物体，并从其上磨掉多余的材料，基本上如所述。

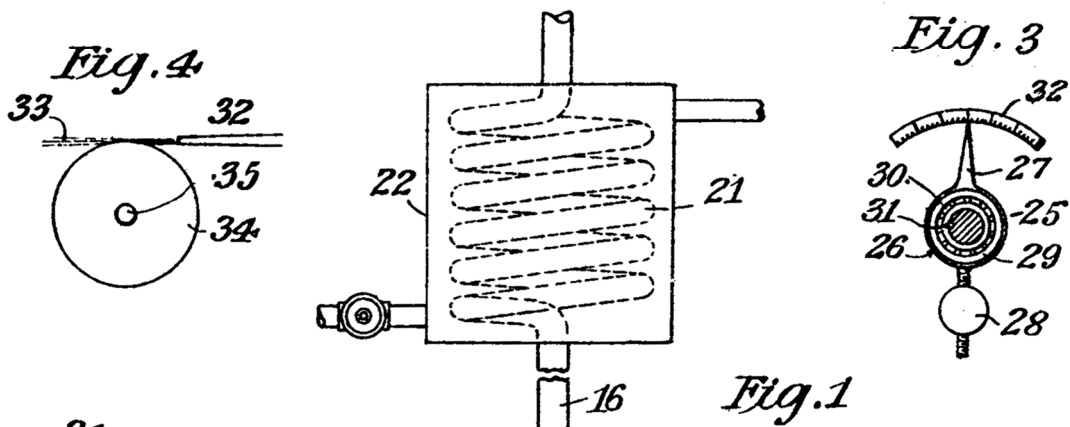
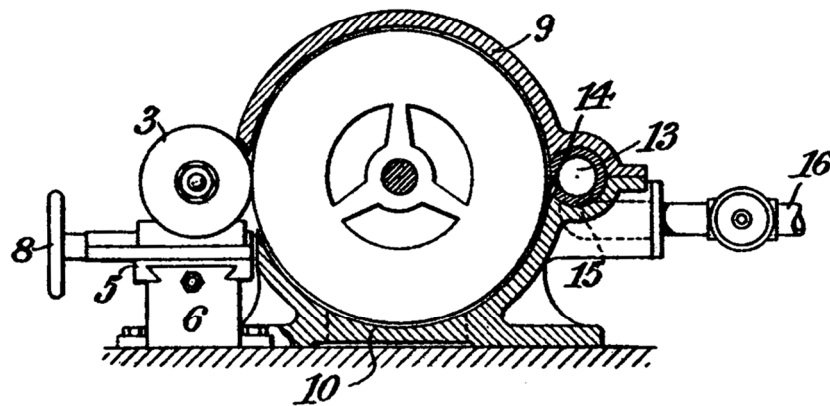
5. The combined apparatus, as shown and described, for the purpose set forth.

5、所示和所述的组合装置用于所述目的。

Dated this 23rd day of August, 1921.

日期为 1921 年 8 月 23 日。

Nikola Tesla.
尼古拉·特斯拉

2nd Edition*Fig. 2*

[This Drawing is a reproduction of the Original on a reduced scale.]

METHOD OF AERIAL TRANSPORTATION.

空中运输方法

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The utility of the aeroplane as a means of transport is materially lessened and its commercial introduction greatly hampered owing to the inherent inability of the mechanism to readily rise and alight, which is an unavoidable consequence of the fact that the required lifting force can only be produced by a more or less rapid translatory movement of the planes or foils. In actual experience the minimum speed for ascension and landing is a considerable fraction of that in full flight, and the principles of design do not admit of a very great advance in this respect without sacrifice of some desirable feature. For this reason planes of very large area, high lift wing-sections, deflectors of the slip-stream of the propeller, or analogous means, which might be helpful in these operations, do not afford the remedy sought. This indispensable high velocity, imperiling life and property, makes it necessary to equip the machine with special appliances and provide suitable facilities at the terminals of the route, all of which entail numerous drawbacks and difficulties of a serious nature. So imperative has it become to devise some plan of doing away with these limitations of the aeroplane that the consensus of expert opinion characterizes the problem as one of the most pressing and important and its practical solution is eagerly awaited by those engaged in the development of the art, as well as the general public.

飞机作为运输工具的实用性在实质上被削弱了，并且由于该机械装置固有的不容易上升和下降的能力，其商业应用受到极大的阻碍，这是以下事实的不可避免的结果，即所需的升力只能通过翼面或翼片的或多或少的快速平移运动来产生。在实际经验中，上升和着陆的最小速度是全力飞行速度的相当大的一部分，在不牺牲设计原理的某些理想特性的情况，难以在这方面有很大的进步。由于这个原因，很大面积的翼面、高升力的机翼剖面、螺旋桨滑流的偏转器或类似的手段，可能有助于这些操作，但不能提供我们寻求的补救措施。这种不可缺少的高速度危及生命和财产，使得有必要为机器配备特殊的装置，并在路线的终点提供适合的设施，所有这些都带来了许多严重的缺陷和困难。因此，迫切需要制定出一项方案来消除飞机的这些限制，以至于专家们一致认为这一问题是最紧迫和最重要的问题之一，并且从事飞机技术发展的人以及普通大众都急切地等待它的切实解决办法。

Many attempts have been made to this end, mostly based on the use of independent devices for the express purpose of facilitating and insuring the start and finish of the aerial journey, but the operativeness of the arrangements proposed is not conclusively demonstrated and, besides, they are objectionable, constructively or otherwise, to such an extent that builders of commercial apparatus have so far not considered them of sufficient value to depart from present practice.

为此，人们已经进行了许多尝试，主要是基于用于方便和确保空中旅行的开始和结束的明确目的的独立的装置的使用，但是，所提议的布置的可操作性并没有得到最后的证明，此外，它们在构造上和其他方面是令人反感的，以至于商业设备的制造者至今还没有认为它们有足够的价值来让他们偏离目前的实践。

More recently, professional attention has been turned to the helicopter which is devoid of planes as distinct organs of support and, presumably, enables both vertical and horizontal propulsion to be satisfactorily accomplished through the instrumentality of the propeller alone. However, although this idea is quite old and not a few experts have endeavored to carry it out in various ways, no success has as yet been achieved. Evidently, this is due to the inadequacy of the engines employed and, perhaps, also to certain heretofore unsuspected characteristics of the device and fallacies in the accepted theory of its operation, an elucidation of which is deemed necessary for the clear understanding of the subject.

最近，专业人员的注意力转向了直升机，这种直升机没有翼面作为明显的支撑机构，而且据推测，它可以仅通过螺旋桨的作用就能令人满意地完成垂直推进和水平推进。然而，尽管这个想法很古老，而且不少专家已经努力用各种方法来实现它，但是还没有取得成功。显然，这是由于使用的发动机的机能不全，也许，也是迄今为止由于设备的某些未被怀疑的特性和有关它的运行的公认理论的谬误，对此的一个澄清对于清楚地理解该主题是必要的。

The prospects of a flying machine of this kind appear at first attractive, primarily because it makes possible the carrying of great loads with a relatively small expenditure of energy. This follows directly from the fundamental laws of fluid propulsion, laid down by W. T. M. Rankine more than fifty years ago, in conformity with which the thrust is equal to the integral sum of the products of the masses and velocities of the projected air particles; symbolically expressed,

$$T = \Sigma(mv).$$

这种飞行器的前景起初看起来很有吸引力，主要是因为它能以相对较小的能量消耗来运载大量的货物。这直接来自威廉·朗肯在五十多年前奠定的流体推进基本定律，根据该定律，推力等于投射的空气粒子的质量和速度的乘积的积分和；象征性地表达，

$$T = \Sigma(mv) \text{ 。}$$

On the other hand, the kinetic energy of the air set in motion is

$$T = \Sigma\left(\frac{1}{2}mv^2\right).$$

另一方面，运动中的空气的动能是

$$T = \Sigma\left(\frac{1}{2}mv^2\right) \text{ 。}$$

From these equations it is evident that a great thrust can be obtained with a comparatively small amount of power simply by increasing the aggregate mass of the particles and reducing their velocities. Taking

a special case for illustration, if the thrust under given conditions be ten pounds per horse-power, then a hundredfold increase of the mass of air, accompanied by a reduction of its effective velocity to one-tenth, would produce a force of one hundred pounds per horsepower. But the seemingly great gain thus secured is of little significance in aviation, for the reason that a high speed of travel is generally an essential requirement which can not be fulfilled except by propelling the air at high velocity, and that obviously implies a relatively small thrust.

从这些方程中可以明显看出，只要增加粒子的总质量（集总质量和惯量统计），并降低它们的速度，就可以用相对较小的功率获得巨大的推力。举一个特殊的例子来说明，如果推力在给定的条件下是每马力 10 磅，那么空气质量增加一百倍，伴随着有效速度减少到十分之一，将产生每马力一百磅的力量。但是，由此获得的看似巨大的收益对航空来说意义不大，因为高速飞行通常是一个基本要求，除非以高速推动空气，否则无法满足要求，这显然意味着相对较小的推力。

Another quality commonly attributed to the helicopter is great stability, this being, apparently, a logical inference judging from the location of the centers of gravity and pressure. It is true, of course, that when the axis of the propeller is vertical and the ambient air quiescent the machine is stable to a degree, but if it is tilted even slightly, or if the medium becomes agitated, such is no longer the case.

另一个通常归因于直升机的品质是很好的稳定性，这显然是一个从重心和压力中心的位置来判断的逻辑推论。当然，当螺旋桨的轴是竖直的，周围的空气静止时，机器在一定程度上是稳定的，但如果螺旋桨稍微倾斜，或者如果介质变得搅动，情况就不再是这样了。

In explanation of this and other peculiarities, assume the helicopter poised in still air at a certain height, the axial thrust T just equaling the weight, and let the axis of the propeller be inclined to form an angle α with the horizontal. The change to the new position will have a twofold effect: The vertical thrust will be diminished to

$$T_v = T \sin \alpha,$$

and at the same time there will be produced a horizontal thrust

$$T_h = T \cos \alpha.$$

在解释这一特性和其他特性时，假设直升机在静止空气中保持一定高度，轴向推力 T 正好等于重量，并使螺旋桨轴倾斜，与水平面成角度 α 。新位置的改变将产生双重影响：垂直推力将减小到

$$T_v = T \sin \alpha,$$

同时会产生一个水平推力

$$T_h = T \cos \alpha.$$

Under the action of the unbalanced force of gravity the machine will now fall along a curve to a level

below and if the inclination of the propeller as well as its speed of rotation remain unaltered during the descent, the forces T , T_v and T_h will continuously increase in proportion to the density of the air until the vertical component T_v of the axial thrust T becomes equal to the gravitational attraction. The extent of the drop will be governed by the inclination of the propeller axis and for a given angle it will be, theoretically, the same no matter at what altitude the events take place. To get an idea of its magnitude suppose the elevations of the upper and lower strata measured from sea level be h_1 , and h_2 , respectively, d_1 and d_2 the corresponding air densities and $H = 26,700$ feet the height of the “uniform atmosphere,” then as a consequence of Boyle's law the relation will exist

$$h_1 - h_2 = H \log \frac{d_2}{ed_1}.$$

在未被平衡的重力作用下，机器现在将沿着曲线下降到下方的一个水平，并且如果在下降过程中螺旋桨的倾斜度及其转速保持不变，力 T 、 T_v 和 T_h 将不断地与空气的密度成正比地增加，直到轴向推力 T 的垂直分量 T_v 变得等于重力吸引力。下降的程度将由螺旋桨轴的倾斜度决定，对于给定的角度，理论上，无论事件发生在什么高度，下降的程度都是相同的。为了获得其大小的概念，假设从海平面测量的上层和下层的海拔分别为 h_1 和 h_2 ， d_1 和 d_2 为相应的空气密度， $H = 26,700$ 英尺为“均匀大气”的高度，那么作为波义耳定律的结果，将存在该关系

$$h_1 - h_2 = H \log \frac{d_2}{ed_1}。$$

It is evident that $\frac{T}{T_v} = \frac{T}{T \sin \alpha} = \frac{1}{\sin \alpha}$ must be equal to $\frac{d_2}{d_1}$, in order that the vertical component of

the axial thrust in the lower stratum should just support the weight. Hence $h_1 - h_2 = H \log_e \frac{1}{\sin \alpha}$.

Taking, in a special case, the angle $\alpha = 60^\circ$, then $\frac{1}{\sin \alpha} = \frac{1}{0.866} = 1.1547$ and $h_1 - h_2 = 26,700 \times \log_e 1.1547 = 3,840$ feet.

很明显 $\frac{T}{T_v} = \frac{T}{T \sin \alpha} = \frac{1}{\sin \alpha}$ 必须等于 $\frac{d_2}{d_1}$ ，以便在下层中轴向推力的垂直分量刚好支撑重量。

因此 $h_1 - h_2 = H \log_e \frac{1}{\sin \alpha}$ 。在一个特殊情况下，取角度 $\alpha = 60^\circ$ ，则 $\frac{1}{\sin \alpha} = \frac{1}{0.866} = 1.1547$

并且 $h_1 - h_2 = 26,700 \times \log_e 1.1547 = 3,840$ 英尺。

In reality the drop will be much greater for the machine, upon reaching the lower layer with a high velocity relative to the medium, will be urged further down along the curved path and the kinetic energy, in the vertical sense, possessed by the moving mass must be annihilated before the fall is arrested in a still denser air stratum. At this point the upward thrust will be far in excess of the opposed pull of the weight and the apparatus will rise with first increasing and then diminishing speed to a height which may approximate the original. From there it will again fall and so on, these operations being repeated during the forward flight, the up and down excursions from the main horizontal line gradually

diminishing in magnitude. After a lapse of time, determined by numerous influences, the excursions should cease altogether and the path described become rectilinear. But this is next to impossible as can be readily shown by pointing out another curious feature of the helicopter.

实际上,对于机器来说,在以相对于介质的高速度到达下层时,下落将会大得多,将会沿着弯曲路径被进一步向下推动,并且在下落在更稠密的空气层中被阻止之前,运动物体在垂直方向上所拥有的动能必须被消除。在这一点上,向上的推力将远远超过重量的反向拉力,该装置将以先增后减的速度上升到接近原来的高度。从那里它将再次下降,诸如此类,这些操作在向前飞行期间重复,从主水平线向上和向下偏移的幅度逐渐减小。经过一段时间后,由众多的影响决定,偏移应该完全停止,所描述的路径成为直线。但这几乎是不可能的,因为通过指出直升机的另一个奇怪的特征就可以很容易地看出这一点。

In the foregoing the axis of the propeller was supposed to move always parallel to itself, which result might be accomplished by the use of an adjustable aileron. In this connection it may be pointed out, however, that such a device will not act in the manner of a rudder, coming into full play at intervals only and performing its functions economically, but will steadily absorb energy, thus occasioning a considerable waste of motive power and adding another to the many disadvantages of the helicopter.

在前文中的螺旋桨轴应该总是平行于自己移动,这个结果可能是通过使用一个可调节的副翼来实现。然而,在这方面可以指出,这种装置不会像方向舵那样发挥作用,仅是有时间间隔地充分发挥作用并经济地执行其功能,但会稳定地吸收能量,因此造成动力的相当大的浪费,并增加了直升机的许多缺点。

Let now the machine be possessed of a certain degree of freedom, as will be the case normally, and observe in the first place that the blades of the propeller themselves constitute planes developing a reaction thrust, the pressure on the lower leading blade being greater than that exerted on the higher one owing to the compression of the air by the body of the machine and increased density in that region. This thrust, tending to diminish the angle α , will obviously vary during one revolution, being maximum in a position when the line of symmetry of the two propeller blades and that of flight are in a vertical plane and minimum at right angles to it. Nevertheless, when the horizontal speed is great it may be considerable and sufficient to quickly overcome the inertia and gyroscopic resistances all the more readily as the upper blade, which is situated in a region where the conditions are more nearly normal, operates to the same effect. Moreover, this disturbing effect partakes of the regenerative quality, the force increasing as the angle diminishes up to a maximum for $\alpha = 45^\circ$. As the axis is tilted more and more, the vertical sustaining effort of the propeller will correspondingly diminish and the machine will fall with a rapidly increasing velocity, finally exceeding the horizontal when the reaction of the blades will be directed upward so as to increase the angle α and thereby cause the machine to soar higher. Thus periodic oscillations accompanied by ascents and descents, will be set up which may well be magnified to an extent such as to bring about a complete overturn and plunge to earth.

现在让机器拥有一定的自由度,通常情况下,首先观察螺旋桨的叶片本身构成产生反推力的翼面,由于机器对空气的压缩和该区域空气密度的增加,较低的前导叶片上的压力大于施加在较高叶片上的压力。这个推力,倾向于减少角度 α ,显然会在一次旋转过程中发生变化,当这两个螺旋桨叶片的对称线和飞行方向在同一个竖直平面内时,该推力最大,当该对称线与飞行方向成直角时,该推力最小。然而,如果水平速度很大,推力可能是相当大的,并且

足以快速克服惯性和陀螺阻力，因为运行中的较上叶片更容易达到相同的效果。此外，这种扰动效应也是再生性品质的一部分，力随着角度的减小而增大，直到 $\alpha = 45^\circ$ 时达到最大值。随着轴倾斜得越来越多，螺旋桨的竖直支撑力将相应地减小，并且机器将以快速增加的速度下落，最终越过水平平面，此时叶片的反作用力将指向上方，从而增加角度 α ，从而使机器飞得更高。因此，伴随着上升和下降的周期性振荡将会产生，这种振荡很可能被放大到导致一次彻底的翻转并坠向地面。

It is held by some experts that the helicopter, because of its smaller body resistance, would be capable of a higher speed than the aerophane. But this is an erroneous conclusion, contrary to the laws of propulsion. It must be borne in mind that in the former type, the motive power being the same, a greater mass of air must be set in motion with a velocity smaller than in the latter, consequently it must be inferior in speed. But even if the air were propelled in the direction of the axis of the screw with the same speed V in both of them, while the aeroplane can approximate the same, the helicopter could never exceed the horizontal component $V \cos \alpha$. To be explicit, imagine that the air current flowing with the velocity V along the propeller axis inclined to form an angle α with the horizontal, be replaced by two streams one vertical and the other horizontal of velocities respectively equal to $V \sin \alpha$ and $V \cos \alpha$, it will be evident that a helicopter in its forward flight could only approximate and never equal the speed $V \cos \alpha$ of the horizontal air current no matter how much the resistance be reduced for, according to a fundamental law of propulsion, the thrust would be nil at that velocity. The highest efficiency should be obtained with the machine proceeding at the rate $\frac{1}{2} V \cos \alpha$ but the most economical utilization of power would be effected when $\alpha = 45^\circ$ in which case the speeds of both the horizontal and vertical streams will be $0.7 V$. From this it may be inferred that, theoretically, the best performance might be secured in propelling the helicopter forward with a speed more or less approximating $0.35 V$ but the results attained in practice will be necessarily much inferior because without special provisions such as are herein set forth the device, as pointed out above, would plunge down and shoot up in succession, at the same time executing smaller oscillations, which motions will retard its flight and consume a considerable portion of the motive energy all the more so as the losses incident to the controlling means will be correspondingly increased.

一些专家认为，由于直升机的机体阻力较小，所以它的速度会比飞机高。但这是一个错误的结论，违背了推进定律。必须记住，在前一种类型中，在动力相同的情况下，必须使更大质量的空气以比后者更小的速度运动，因此它的速度一定较低。但是，即使空气以相同的速度 V 沿螺旋轴的方向被推进，虽然飞机可以近似相同，但直升机永远不会超过水平分量 $V \cos \alpha$ 。明确地说，设想沿螺旋桨轴线以速度 V 流动的气流与水平面成角度 α ，由两股气流代替，一股竖直气流和另一股水平气流，速度分别等于 $V \sin \alpha$ 和 $V \cos \alpha$ ，很明显，直升机在向前飞行时只能接近但永远不会等于水平气流的速度 $V \cos \alpha$ ，无论阻力减小多少，根据推进的基本定律，在那个速度下推力为零。当机器以速度 $\frac{1}{2} V \cos \alpha$ 飞行时应获得最高效率，但当 $\alpha = 45^\circ$ 时，最经济的功率利用将会实现，在这种情况下，水平气流和垂直气流的速度都将为 $0.7 V$ 。由此可以推断，从理论上讲，以接近 $0.35 V$ 的速度向前推进直升机可以确保最佳性能，但是在实践中获得的结果必然要差得多，因为如果没有在这里前述的特殊措施，如上所述，该装置将连续向下俯冲和向上跳跃，同时执行较小的振荡，这些运动将阻碍其飞行并消耗相当大一部分的动能，因此控制装置的损耗将相应增加。

Another very serious defect of this kind of flying machine, from the practical point of view, is found in its inability of supporting itself in the air in case of failure of the motor, the projected area of the propeller blades being inadequate for reducing the speed of the fall sufficiently to avoid disaster, and this is an almost fatal impediment to its commercial use.

从实用的角度来看，这种飞行器的另一个非常严重的缺陷是，在发动机发生故障的情况下，它不能在空中支撑自己，螺旋桨叶片的投影面积不足以充分降低下落的速度以避免灾难，这几乎是其商业应用的致命障碍。

From the preceding facts, which are ignored in the technical publications on the subject, it will be clear that the successful solution of the problem is in a different direction.

从前面的事实（在关于这个主题的技术出版物中被忽略了）可以清楚地看出，问题的成功解决是在另一个不同的方向上。

My invention meets the present necessity in a simple manner without radical departure in construction and sacrifice of valuable features, incidentally securing advantages which should prove very beneficial in the further development of the art. Broadly expressed, it consists in a novel method of transporting bodies through the air according to which the machine is raised and lowered solely by the propeller and sustained in lateral flight by planes. To accomplish this a light and powerful prime mover is necessary and as particularly suited for the purpose I employ, preferably, a turbine of the kind described in my U. S. Patent No. 1,061,206, of May 6, 1913, which not only fulfills these requirements, but is especially adapted to operation at high temperature. I also make arrangements whereby the flying machine may be, automatically or at will of the operator, caused to function either as a helicopter or an aeroplane.

我的发明以简单的方式满足了当前的需要，而没有在结构上的根本偏离和牺牲有价值的特征，顺便确保了在本领域的进一步发展中应该证明非常有益的优点。概括地说，它包括一种在空中运输物体的新方法，根据这种方法，机器仅由螺旋桨就能上升和下降，并由翼面保持横向飞行。为了实现这一点，需要一种重量轻、功率大的原动机，这种原动机特别适合于我所采用的目的，最好是我在1913年5月6日的美国专利第1,061,206号中所描述的那种涡轮机，它不仅能满足这些要求，而且特别适合于在高温下运行。我还做出布置，使飞行器可以自动地或按照操作者的意愿用作直升机或飞机。

Full knowledge of these improvements will be readily gained by reference to the accompanying drawings in which Fig. 1 illustrates the machine in the starting or landing position and Fig. 2, in horizontal flight. Fig. 3 is a plan view of the same with the upper plane partly broken away.

通过参考附图，将容易获得这些改进的全部知识，在附图中，图1展示了处于起飞位置或着陆位置的机器，图2展示了处于水平飞行状态的机器。图3是它的上翼面被部分剖开的平面图。

The structure is composed of two planes or foils 1, 1 rigidly joined. Their length and distance apart may be such as to form a near-square for the sake of smallness and compactness. With the same object the tail is omitted or, if used, it is retractable. The motors 2, 2 in this case turbines of the kind described in my patent before referred to, and other parts of the motive apparatus are placed with due regard to the

centers of gravity and pressure and the usual controlling means are provided. In addition to these any of the known stabilizing devices may be embodied in the machine. At rest the planes are vertical, or nearly so, and likewise the shaft driving the propeller 3, which is constructed of a strength, size and pitch that will enable it to raise the entire weight with the motors running at an even greater rate than when propelling the machine horizontally. Power is transmitted to the shaft from the turbines through suitable gears. The seats 4, 4, 4 for the operator and passengers are suspended on trunnions 5, 5 on which they can turn through an angle of about 90° , springs and cushions (not shown) being employed to insure and limit their motion through this angle. The usual devices for lateral and directional control, 6, 6 7, 7 and 8, 8 are provided with mechanical connections enabling the operator to actuate the devices by hand or foot from his seat in any position. At the start, sufficient power being turned on by suitable means, also within his reach, the machine rises vertically in the air to the desired height when it is gradually tilted by manipulating the elevator devices and proceeds like an aeroplane, the load being transferred from the propeller to the foils as the angle of inclination diminishes and the speed in horizontal direction increases. From the foregoing it will be understood that, simultaneously with the tilting of the machine, the operator will increase the thrust of the propeller in order to compensate for the reduction of sustaining force which follows inevitably from the diminution of angle α and before the reaction of the planes can come into full effect. He will thus prevent a downward plunge and the production of dangerous oscillations which have been dwelt upon above, and by suitable manipulation of the apparatus and gradual cutting down of the power developed by the prime mover, as forward velocity is gained and the planes take up the load, he may cause the machine to advance horizontally along a sensibly straight line, a condition essential to the attainment of the best practical results. In descending, the forward speed is reduced and the machine righted again, acting as a helicopter with the propeller supporting all the load. Obviously, as the device is slowed down and righted causing the planes to lose part or all of their sustaining efforts, the operator will apply more power to the propeller increasing thereby the thrust to the required magnitude and in all such operations of starting and loading as well as tilting for regulating the height, meeting the air conditions or for other purposes it will be his object to modify the propeller thrust in about the same measure as the varying reaction of the planes may demand in order that the lifting force be sensibly constant. Evidently also, whenever necessary or desirable, power far in excess of that normally required may be applied during the flight and the machine propelled at a greatly increased speed. The type of turbine used is a motor of great lightness and activity and lends itself exceptionally to this kind of work for which ordinary aviation motors are unsuited. It is capable of carrying a great overload and running without danger at excessive speed so that during the starting and landing operations the necessary power can be developed by the motors even though less efficiently than under their normal working conditions. Special means of control may be provided, if necessary, for increasing the power supply in these operations. Owing to its extreme simplicity the motive apparatus is reliable in operation, but should the power give out accidentally, landing can still be easily effected by volplaning. For this purpose, in addition to wheels 9, 9 and 10, 10 wheels 11, 11 are employed, the latter being mounted on the forward end under the lower plane and so that when the machine rests on level ground the propeller shaft will have the desired inclination which is deemed best for rising in the manner of an aeroplane. Such an aeroplane constructed and operated as described, unites the advantages of both types and seems to meet best the requirements of a small, compact, exceedingly speedy and yet very safe machine for commercial use. Especially good practical results are obtainable by the use of my turbine which can be depended upon to develop the necessary energy for lifting, even if it should be considerably greater than that consumed in flight under normal conditions. This end can be conveniently attained by temporarily supplying more of the working fluid to the rotor

and driving it faster, or running it at about the same speed and increasing the effort by adjustment of the pitch of the propeller, or other means known in the art. The latter should be designed to work most economically during the flight, as its efficiency in the starting and landing operations is of relatively small importance. Instead of a single large screw as described a number of smaller ones may be used, in which case gearing can be dispensed with. The biplane seems to be best suited for the chief purpose contemplated but the invention is applicable to monoplanes and other types.

该结构由刚性连接的两个翼面或翼片 1、1 组成。为了小和紧凑，它们的长度和分开的距离可以形成近似正方形。出于同样的目的，尾巴被省略，或者如果使用，它是可伸缩的。发动机 2、2（在这种情况下是前面提到的我的专利中描述的那种涡轮机）和动力装置的其它部件适当考虑重力中心和压力中心来放置，并且配备了通常的控制装置。除此之外，任何已知的稳定装置都可以被包含在机器中。在静止时，这些翼面是竖直的，或者接近竖直，驱动螺旋桨 3 的轴也是如此，螺旋桨 3 的强度、尺寸和螺距使得它能够在发动机以比水平推进机器的速度更高的速度运转的情况下提升整个重量。动力通过合适的齿轮从涡轮传递到轴上。用于操作者和乘客的座椅 4、4、4 被悬挂在耳轴 5、5 上，他们可以在耳轴 5、5 上转过大约 90° 的角度，使用弹簧和垫子（未展示）来保证和限制他们在该角度内的运动。用于横向和方向控制的常用装置 6、6、7、7 和 8、8 配有机机械连接，使得操作者能够在任何位置从其座位上用手或脚来驱动这些装置。开始时，通过合适的装置（也在他的能够触及的范围内）打开足够的动力，机器在空中垂直上升到期望的高度，当机器通过操纵升降装置逐渐倾斜，并像飞机一样前进时，随着倾角减小和水平方向的速度增加，负载从螺旋桨转移到翼片。从前述内容可以理解，在机器倾斜的同时，操作者将增加螺旋桨的推力，以补偿支撑力的减小，这种减小不可避免地伴随着角度 α 的减小，并且是在翼面的反作用力完全生效之前。因此，他将防止上文已经详述的一个向下的急坠和多个危险的振荡的产生，并通过装置的适当操作和原动机产生的功率的逐渐减少，随着前进速度的增加和翼面举起负载，他可能会使得机器沿着一条明显的直线水平地前进，这是获得最佳实际结果的必要条件。在下降过程中，前进速度降低，机器再次恢复平衡，就像一架直升机，由螺旋桨支撑全部载荷。显然，当该装置被减速和扶正，导致翼面失去部分或全部的支撑力时，操作者将向螺旋桨施加更多的动力，从而将推力增加到所需的大小，并且在所有这种起动和装载以及为了调节高度、满足空气条件或为了其他目的倾斜操作中，他的目的是根据翼面可能要求的不同反作用力来修正螺旋桨推力，以使升力明显地保持不变。同样明显的是，无论何时需要或希望，在飞行过程中，可以施加远远超过正常所需的功率，并以大大增加的速度推进机器。所用的涡轮是一种重量轻、动力大的发动机，特别适合于这种普通航空发动机不适合的工作。它能够承载很大的过载，并且以过高的速度运行而没有危险，因此在起飞和着陆操作期间，即使发动机效率低于正常工作条件下的效率，发动机也能够产生必要的功率。如果需要，可以提供特殊的控制手段，以增加这些操作中的功率供应。由于其极其简单的动力装置在运行上是可靠的，但如果意外地失去动力，着陆仍然可以很容易地通过滑行来实现。为此目的，除了轮 9、9 和 10、10 之外，还使用了轮 11、11，后者被安装在下翼面下方的前端上，从而当机器停留在水平地面上时，螺旋桨轴将具有期望的倾斜度，该倾斜度被认为最适于以翼面的方式上升。这种飞机的结构和操作如上所述，结合了两两种飞机的优点，似乎最能满足小型、紧凑、速度极快但又非常安全的商用飞机的要求。使用我的涡轮机可以获得特别好的实际结果，可以依靠它来产生拉升所需的能量，即使拉升应该比正常条件下飞行消耗的能量大得多。通过暂时向转子供应更多的工作流体并更快地驱动转子，或者以大约相同的速度运行转子并通过调节螺旋桨的螺距或本领域已知的其它方式来增加作用力，可以方便地实现这一目的。螺旋桨应被设计成在飞行中最经济地工作，因为它在起动和着陆操作中的效率相对来说不太重要。代替所述的单个大螺杆，可以使用多个较小的螺杆，在这种情况下可以省去传动装置。双翼飞机似乎最适

合预期的主要目的，但是本发明适用于单翼飞机和其他类型。

To sum up, the helicopter type of flying machine, especially with large inclination angle of the propeller axis to the horizontal, at which it is generally expected to operate, is quite unsuitable for speedy aerial transport; it is incapable of proceeding horizontally along a straight line under the prevailing air conditions; it is subject to dangerous plunges and oscillations and, what is most important from the commercial and practical point of view, it is almost certainly doomed to destruction in case the motive power gives out. These drawbacks and defects are overcome by the methods and apparatus I have described through which a novel type of flying machine may be realized possessing all the advantages of the helicopter being at the same time safe and capable of a speed equal to or even greatly exceeding that of the present aeroplane.

总之，直升机类型的飞行器，特别螺旋桨轴与水平面倾角较大的飞行器，通常期望在这种倾角下运行，非常不适合于快速的空中运输；在当时的空气条件下，它不能沿直线水平前进；它容易发生危险的急坠和摆动，而且从商业和实用的角度来看，最重要的是，如果动力耗尽，它几乎注定会毁灭。这些缺点和缺陷通过我已经描述的方法和设备来克服，通过这些方法和设备，可以实现一种新型的飞行器，它具有直升机的所有优点，同时是安全的，并且能够达到等于甚至大大超过现有飞机的速度。

To my knowledge various forms of aeroplanes have been proposed with the object of attaining similar results but a careful study shows that none of them is capable of the actions as those here contemplated for want of proper methods of operation as well as suitable apparatus.

据我所知，已经提出了各种形式的飞机，目的是获得类似的结果，但仔细研究表明，由于缺乏适当的操作方法和合适的设备，它们中没有一种能够起到这里设想的作用。

I do not claim herein the apparatus by means of which this method is or may be carried out either in the special form illustrated or in modifications of the same, as this is the subject of a separate application.

在此，我不主张利用该方法的装置，或者要么在已说明的特定形式中使用的装置，要么在改进形式中使用的装置，因为这是不同申请的主题。

What I desire to secure by Letters Patent is:

我希望通过专利证书得到确保的是:

1. The hereinbefore described method of aeroplane transportation which consists in developing by the propelling device a vertical thrust in excess of the normal, causing thereby the machine to rise in an approximately vertical direction, tilting it and simultaneously increasing the power of the motor and thereby the propeller thrust, then gradually reducing the power and thrust as forward speed is gained and the planes take up the load, thus maintaining the lifting force sensibly constant during flight, tilting the machine back to its original position and at the same time increasing the power of the motor and thrust of the propeller and effecting a landing under the restraining action of the same.

1、上文所述的飞机运输方法，包括：通过推进装置产生超过正常水平的垂直推力，从而使

机器在近似垂直的方向上升，使其倾斜，同时增加发动机的功率，从而增加螺旋桨推力，然后随着前进速度的增加和翼面举起负载，逐渐减小功率和推力，从而在飞行过程中保持升力明显恒定，将机器倾斜回到其初始位置，同时增加发动机的功率和螺旋桨的推力，并在其约束作用下实现着陆。

2. The method of operating a helicopter which consists in varying the power of the motor and thereby the thrust of the propeller according to the changes of inclination of its axis, so as to maintain the lifting force sensibly constant during the forward flight.

2、一种操作直升机的方法，包括根据轴倾角的变化改变发动机的功率，从而改变螺旋桨的推力，以便在向前飞行期间保持升力明显恒定。

3. The above described method of transporting from place to place a heavier than air flying machine, which consists in applying power to the propeller while its axis is in a vertical position sufficient to cause the machine to rise, tilting it and at the same time applying more power to increase the thrust, then gradually diminishing the power as the load is transferred from the propeller to the planes, tilting back the machine and so controlling the applied power as to effect a slow descent upon the landing place under the restraining action of the propeller.

3、上述的将比空气重的飞行器从一个地方运输到另一个地方的方法，包括：当螺旋桨的轴处在足以使飞行器上升的竖直位置时，向螺旋桨施加动力，使其倾斜，同时施加更多的动力以增加推力，然后随着载荷从螺旋桨转移到翼面上，逐渐减小动力，使飞行器向后倾斜，从而控制所施加的动力，以便在螺旋桨的约束作用下在着陆点上实现缓慢下降。

4. In the transport of bodies by aeroplane, the method of controlling the propeller thrust and reaction of the planes by varying the power of the motor correspondingly with the inclination of the machine so as to maintain the lifting force sensibly constant during the forward flight.

4、在用飞机运输物体时，根据机体的倾斜度相应地改变电动机的功率来控制螺旋桨的推力和翼面的反作用，从而在向前飞行过程中保持升力的合理恒定。

In testimony whereof I hereto affix my signature.

我在此签名为证。

NIKOLA TESLA.

尼古拉·特斯拉

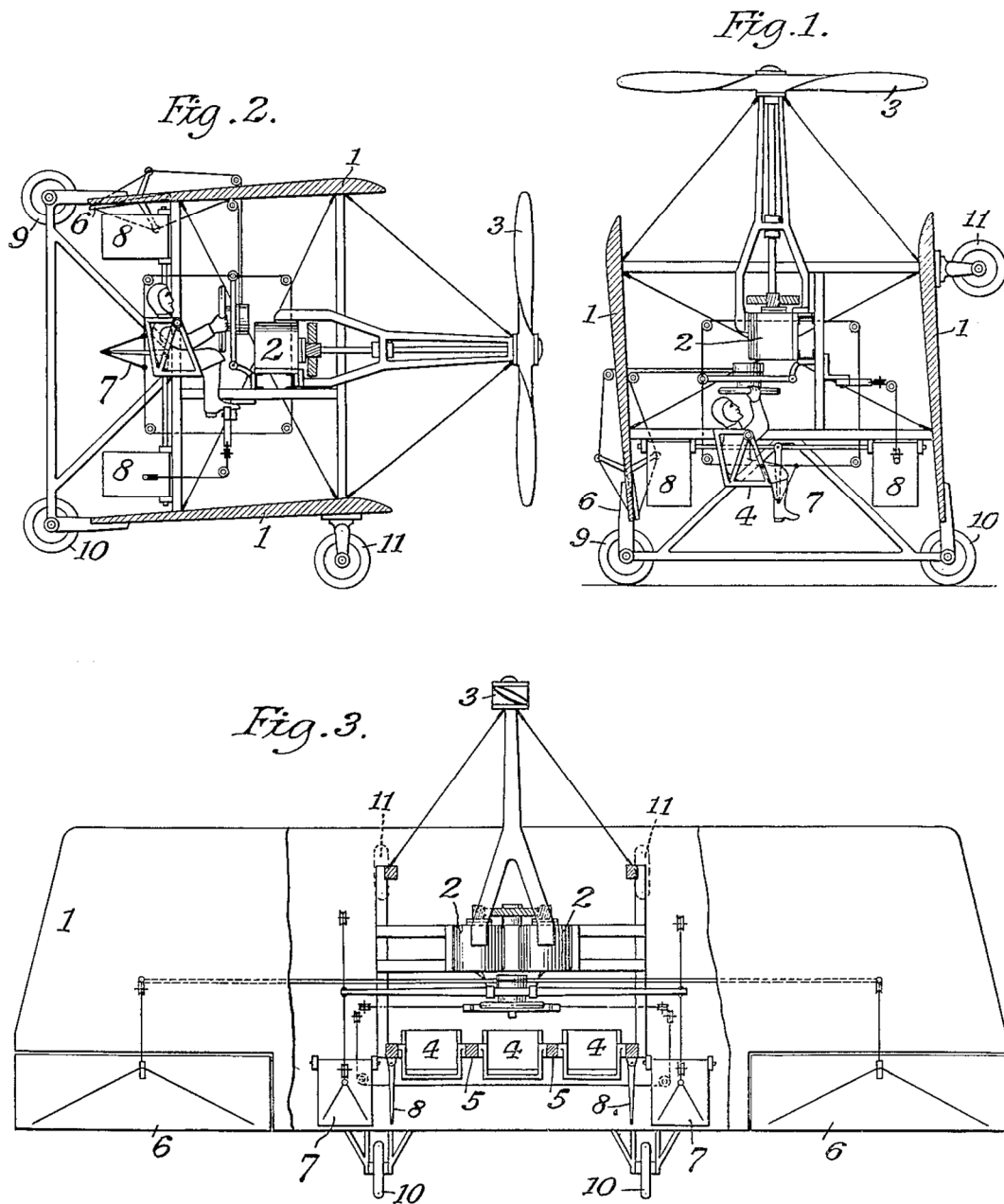
Jan. 3, 1928.

1,655,113

N. TESLA

METHOD OF AERIAL TRANSPORTATION

Filed Sept. 9, 1921



Nikola Tesla INVENTOR
BY *Ken. Rags. Corbin & Haywood*
ATTORNEYS.

APPARATUS FOR AERIAL TRANSPORTATION.

用于空中运输的装置

NIKOLA TESLA, OF NEW YORK, N. Y.

纽约州纽约市的尼古拉·特斯拉

Application filed October 4, 1927. Serial No. 223,915.

该申请于 1927 年 10 月 4 日提交。序列号为 223,915。

This application is a continuation in part of my application Serial No. 499,518, filed September 9, 1921, and is made pursuant to the rules of the Patent Office, its purpose being to describe and claim apparatus which I have invented for carrying into practice the method therein disclosed.

本申请是我于 1921 年 9 月 9 日提交的序列号为 499,518 的申请的一部分的延续，并且是根据专利局的规定提出的，其目的是描述和主张我发明的用于实施其中公开的方法的装置。

The invention consists of a new type of flying machine, designated “helicopter-plane”, which may be raised and lowered vertically and driven horizontally by the same propelling devices and comprises: a prime mover of improved design and an airscrew, both especially adapted for the purpose, means for tilting the machine in the air, arrangements for controlling its operation in any position, a novel landing gear and other constructive details, all of which will be hereinafter fully described.

本发明包括一种称为“直升机飞机”的新型飞行器，它可以通过相同的推进装置垂直上升和垂直下降以及水平推动，并且包括：一个螺旋桨和改进设计的一个原动机，两者都特别适用于该目的；用于在空中倾斜该机器的装置；用于在任何位置控制其操作的装置；一个新颖的起落架和其他结构细节，所有这些将在下文充分描述。

The utility of the aeroplane as a means of transport is materially lessened and its commercial introduction greatly hampered owing to the inherent inability of the mechanism to readily rise and alight, which is an unavoidable consequence of the fact that the required lifting force can only be produced by a more or less rapid translatory movement of the planes or foils. This indispensable high velocity, imperiling life and property, makes it necessary to equip the machine with special appliances and provide suitable facilities at the terminals of the route, all of which entail numerous drawbacks and difficulties of a serious nature.

飞机作为运输工具的实用性在实质上被削弱了，并且由于该机械装置固有的不容易上升和下降的能力，其商业应用受到极大的阻碍，这是以下事实的不可避免的结果，即所需的升力只能通过翼面或翼片的或多或少的快速平移运动来产生。这种不可缺少的高速度危及生命和财产，使得有必要为机器配备特殊的装置，并在路线的终点提供适合的设施，所有这些都带来了许多严重的缺点和困难。

More recently, professional attention has been turned to the helicopter which is devoid of planes as distinct organs of support and, presumably, enables both vertical and horizontal propulsion to be satisfactorily accomplished through the instrumentality of the propeller alone.

最近，专业人员的注意力转向了直升机，这种直升机没有翼面作为明显的支撑结构，而且据推测，它可能仅通过螺旋桨的作用就能令人满意地完成垂直和水平推进。

The prospects of such a flying machine appear at first attractive, primarily because it makes possible the carrying of great weight with a relatively small expenditure of energy. This follows directly from the fundamental laws of fluid propulsion, laid down by W. T. M. Rankine more than fifty years ago, in conformity with which the thrust is equal to the integral sum of the products of the masses and velocities of the projected air particles; symbolically expressed,

$$T = \Sigma(mv).$$

这种飞行器的前景起初看起来很有吸引力，主要是因为它能以相对较小的能量消耗来运载大量的货物。这直接来自威廉·朗肯在五十年前奠定的流体推进基本定律，根据该定律，推力等于投射的空气粒子的质量和速度的乘积的积分和；象征性地表达，

$$T = \Sigma(mv)。$$

On the other hand, the kinetic energy of the air set in motion is

$$T = \Sigma\left(\frac{1}{2}mv^2\right).$$

另一方面，运动中的空气的动能是

$$T = \Sigma\left(\frac{1}{2}mv^2\right)。$$

From these equations it is evident that a great thrust can be obtained with a comparatively small amount of power simply by increasing the aggregate mass of the particles and reducing their velocities. But the seemingly great gain thus secured is of small value in aviation for the reason that a high speed of travel is generally an essential requirement which cannot be fulfilled except by propelling the air at high velocity, and that obviously implies a relatively small thrust.

从这些方程中可以明显看出，只要增加粒子的总质量（集总质量和惯量统计），并降低它们的速度，就可以用相对较小的功率获得巨大的推力。但是，由此获得的看似巨大的收益对航空来说意义不大，因为高速飞行通常是一个基本要求，除非以高速推动空气，否则无法满足要求，这显然意味着相对较小的推力。

Another quality commonly attributed to the helicopter is great stability, this being apparently a logical inference judging from the location of the centers of gravity and pressure. It will be found, though, that contrary to this prevailing opinion the device, while moving in any direction other than up or down, has an equilibrium easily so disturbed and has, moreover, a pronounced tendency to oscillate.

另一个通常归因于直升机的品质是很好的稳定性,这显然是一个从重心和压力中心的位置来判断的逻辑推论。然而,将会发现,与这种主流观点相反,该装置在除了向上或向下之外的任何方向上移动时,它的平衡容易被扰乱,并且还具有一定的振荡趋势。

In explanation of these and other peculiarities, assume the helicopter poised in still air at a certain height, the axial thrust T just equaling the weight, and let the axis of the propeller be inclined to form an angle α with the horizontal. The change to the new position will have a two-fold effect: the vertical thrust will be diminished to

$$T_v = T \sin \alpha.$$

and at the same time there will be produced a horizontal thrust

$$T_h = T \cos \alpha.$$

在解释这一特性和其他特性时,假设直升机在静止空气中保持在一定高度,轴向推力 T 正好等于重量,并使螺旋桨轴倾斜,与水平面成角度 α 。新位置的改变将产生双重影响:垂直推力将减小到

$$T_v = T \sin \alpha,$$

同时会产生一个水平推力

$$T_h = T \cos \alpha。$$

Under the action of the unbalanced force of gravity, the machine will now fall along a curve to a level below and if the inclination of the propeller as well as its speed of rotation remain unaltered during the descent, the forces T , T_v , and T_h will continuously increase in proportion to the density of the air until the vertical component T_v of the axial thrust T becomes equal to the gravitational attraction. The extent of the drop will be governed by the inclination of the propeller axis and for a given angle it will be, theoretically, the same no matter at what altitude the events take place. To get an idea of its magnitude suppose the elevations of the upper and lower strata measured from sea level be h_1 and h_2 , respectively, d_1 and d_2 the corresponding air densities and $H = 26,700$ feet the height of the “uniform atmosphere,” then as a consequence of Boyle's Law the relation will exist

$$h_1 - h_2 = H \log \frac{d_2}{ed_1}.$$

在未被平衡的重力作用下,机器现在将沿着曲线下降到下方的一个水平,并且如果在下降过程中螺旋桨的倾斜度及其转速保持不变,力 T 、 T_v 和 T_h 将不断地与空气的密度成比例地增加,直到轴向推力 T 的垂直分量 T_v 变得等于重力吸引力。下降的程度将由螺旋桨轴的倾斜度决定,对于给定的角度,理论上,无论事件发生在什么高度,下降的程度都是相同的。为了获得其大小的概念,假设从海平面测量的上层和下层的海拔分别为 h_1 和 h_2 , d_1 和 d_2 为相应的空气密度, $H = 26,700$ 英尺为“均匀大气”的高度,那么作为波义耳定律的一个结果,将存在该关系

$$h_1 - h_2 = H \log_e \frac{d_2}{ed_1}。$$

It is evident that $\frac{T}{T_v} = \frac{T}{T \sin \alpha} = \frac{1}{\sin \alpha}$ must be equal to $\frac{d_2}{d_1}$, in order that the vertical component of the axial thrust in the lower stratum should just support the weight. Hence $h_1 - h_2 = H \log_e \frac{1}{\sin \alpha}$.

Taking, in a special case, the angle $\alpha = 60^\circ$, then $\frac{1}{\sin \alpha} = \frac{1}{0.866} = 1.1547$ and $h_1 - h_2 = 26,700 \times \log_e 1.1547 = 3,840$ feet.

很明显 $\frac{T}{T_v} = \frac{T}{T \sin \alpha} = \frac{1}{\sin \alpha}$ 必须等于 $\frac{d_2}{d_1}$, 以便在下层中轴向推力的垂直分量刚好支撑重量。

因此 $h_1 - h_2 = H \log_e \frac{1}{\sin \alpha}$ 。在一个特殊情况下, 取角度 $\alpha = 60^\circ$, 则 $\frac{1}{\sin \alpha} = \frac{1}{0.866} = 1.1547$

并且 $h_1 - h_2 = 26,700 \times \log_e 1.1547 = 3,840$ 英尺。

In reality the drop will be much greater for the machine, upon reaching the lower layer with a high velocity relative to the medium, will be urged further down along the curved path and the kinetic energy, in the vertical sense, possessed by the moving mass must be annihilated before the fall is arrested in a still denser air stratum. At this point the upward thrust will be far in excess of the opposed pull of the weight and the apparatus will rise with first increasing and then diminishing speed to a height which may approximate the original. From there it will again fall and so on, these operations being repeated during the forward flight, the up and down excursions from the main horizontal line gradually diminishing in magnitude. After a lapse of time, determined by numerous influences, these deviations should become insignificant and the path described nearly rectilinear. But this is next to impossible as can be readily shown by pointing out another curious feature of the helicopter.

实际上, 对于机器来说, 在以相对于介质的高速度到达下层时, 下落将会大得多, 将会沿着弯曲路径被进一步向下推动, 并且在下落动作在更稠密的空气层中被阻止之前, 运动物体在垂直方向上所拥有的动能必须被消除。在这一点上, 向上的推力将远远超过重量的反向拉力, 该装置将以先增后减的速度上升到接近原来的高度。从那里它将再次下降, 诸如此类, 这些操作在向前飞行期间重复, 从主水平线向上和向下偏移的幅度逐渐减小。经过一段时间后, 由众多的影响决定, 偏移应该完全停止, 所描述的路径成为直线。但这几乎是不可能的, 因为通过指出直升机的另一个奇怪的特征就可以很容易地看出这一点。

In the foregoing the axis of the propeller was supposed to move always parallel to itself, which result might be accomplished by the use of an adjustable aileron. In this connection it may be pointed out, however, that such a device will not act in the manner of a rudder, coming into full play at intervals only and performing its functions economically, but will steadily absorb energy, this occasioning a considerable waste of motive power and adding another to the many disadvantages of the helicopter.

在前文中的螺旋桨轴应该总是平行于自己移动, 这个结果可以通过使用一个可调节的副翼来实现。然而, 在这方面可以指出, 这种装置不会像方向舵那样发挥作用, 仅是有间隔地充分发挥作用并经济地执行其功能, 但会稳定地吸收能量, 因此造成动力的相当大的浪费,

并增加了直升机的许多缺点。

Let now the machine be possessed of a certain degree of freedom, as will be the case normally, and observe in the first place that the blades of the propeller themselves constitute planes developing a reaction thrust, the pressure on the lower leading blade being greater than that exerted on the higher one owing to the compression of the air by the body of the machine and increased density in that region. This thrust, tending to diminish the angle α , will vary during one revolution, being maximum in a position when the line of symmetry of the two propeller blades and that of flight are in the same vertical plane and minimum when the former is at right angles to it.

现在让机器拥有一定的自由度，通常情况下，首先观察螺旋桨的叶片本身构成产生反推力的翼面，由于机器对空气的压缩和该区域空气密度的增加，较低的前导叶片上的压力大于施加在较高叶片上的压力。这个推力，倾向于减少角度 α ，显然会在一次旋转过程中发生变化，当这两个螺旋桨叶片的对称线和飞行方向在同一个竖直平面内时，该推力最大，当该对称线与飞行方向成直角时，该推力最小。

Nevertheless, if the horizontal speed is great, it may be considerable and sufficient to quickly overcome the inertia and gyroscopic resistances all the more readily as the upper blade operates to the same effect. Moreover, this intermittent action partakes of the regenerative quality, the force increasing as the angle diminishes up to a maximum for $\alpha = 45$ degrees, and may also give rise to disturbing resonant vibrations in the structure. As its axis is tilted more and more, the vertical sustaining effort of the propeller correspondingly diminishes and the machine will fall with a rapidly increasing velocity, which may finally exceed the horizontal, when the reaction of the blades is directed upward so as to increase the angle α and thereby cause the machine to soar higher. Thus periodic oscillations, accompanied by ascents and descents, will be set up which may well be magnified to an extent such as to bring about a complete overturn and plunge to earth.

然而，如果水平速度很大，推力可能是相当大的，并且足以快速克服惯性和陀螺阻力，因为运行中的较上叶片更容易达到相同的效果。此外，这种间歇性的动作也是再生品质的一部分，力随着角度的减小而增大，直到 $\alpha = 45^\circ$ 时达到最大值，并且还可能在结构中引起干扰共振。随着轴倾斜得越来越多，螺旋桨的竖直支撑力将相应地减小，并且机器将以快速增加的速度下落，最终越过水平平面，此时叶片的反作用力将指向上方，从而增加角度 α ，使机器飞得更高。因此，伴随着上升和下降的周期性振荡将会产生，这种振荡很可能被放大到导致一次彻底的翻转并坠向地面。

It is held by some experts that the helicopter, because of its smaller body resistance, would be capable of a higher speed than the aeroplane. This is an erroneous conclusion, contrary to the laws of propulsion. It must be borne in mind that in the former type, the motive power being the same, a greater mass of air must be set in motion with a velocity smaller than in the latter, consequently it must be inferior in speed. But even if the air were propelled in the direction of the axis of the screw with the same speed V in both of them, while the aeroplane approximates the same, the helicopter can never exceed the horizontal component $V \cos \alpha$ which, under the theoretically most economical conditions of operation, would only be $0.7V$, and this would be true no matter how much its resistance is reduced.

一些专家认为，由于直升机的机体阻力较小，所以它的速度会比飞机高。这是一个错误的结

论, 违背了推进定律。必须记住, 在前一种类型中, 在动力相同的情况下, 必须使更大质量的空气以比后者更小的速度运动, 因此它的速度一定较低。但是, 即使空气在螺旋轴的方向上以同样的速度 V 推进, 而飞机近似相同, 直升机永远不会超过水平分量 $V \cos a$, 在理论上最经济的操作条件下, 它只会是 $0.7V$, 这将是真实的, 无论它的阻力减少多少。

Another very serious defect of this kind of flying machine, from the practical point of view, is found in its inability of supporting itself in the air in case of failure of the motor, the projected area of the propeller blades being inadequate for reducing the speed of the fall sufficiently to avoid disaster, and this is an almost fatal impediment to its commercial use.

从实用的角度来看, 这种飞行器的另一个非常严重的缺点是, 在发动机发生故障的情况下, 它不能在空中支撑自己, 螺旋桨叶片的投影面积不足以充分降低下落的速度以避免灾难, 这几乎是其商业应用的致命障碍。

From the preceding facts, which are ignored in the technical publications on the subject, it will be clear that the successful solution of the problem is in a different direction.

从前面的事实(在关于这个主题的技术出版物中被忽略了)可以清楚地看出, 问题的成功解决是在一个不同的方向上。

In an application of even date, referred to above, I have disclosed an invention which meets the present necessity in a simple manner and, briefly stated, consists in a novel method of transporting bodies through the air according to which the machine is raised and lowered solely by the propeller and sustained in lateral flight by planes.

在上面提到的同一日期的申请中, 我已经公开了一项发明, 该发明以简单的方式满足了当前的需要, 并且简单地说, 该发明包括一种在空中运输物体的新颖方法, 根据该方法, 机器仅通过螺旋桨就能上升和下降, 并且通过翼面保持横向飞行。

My present application is based on new and useful features and combinations of apparatus which I have devised for carrying this method into practice.

我目前的申请是基于新的和有用的特征和装置的组合, 这些特征和组合是我为了将这种方法付诸实践而设计的。

Full knowledge of these improvements will be readily gained by reference to the accompanying drawings in which Fig. 1 illustrates the machine in the starting or landing position and Fig. 2 in horizontal flight; Fig. 3 is a plan view of the same with the upper plane partly broken away and Fig. 4 and Fig. 5 sectional views of constructive details.

通过参考附图, 将容易获得这些改进的全部知识, 在附图中, 图 1 展示了处于起飞或着陆位置的机器, 图 2 展示了处于水平飞行状态的机器; 图 3 是它的上翼面被部分剖开的平面图, 图 4 和图 5 是构造细节的剖视图。

The structure is composed of two planes or foils 1, 1 rigidly joined. Their length and distance apart may

be such as to form a near-square for the sake of smallness and compactness. With the same object the tail is omitted or, if used, it is retractable. In order to raise the machine vertically a very light and powerful prime mover is necessary and as particularly suited for the purpose, I employ, preferably, a turbine described in my U. S. Patent 1,061,206 of May 6, 1913, which not only fulfills these requirements but lends itself especially to operation at very high temperatures. Two such turbines, designated 2, 2 together with other parts and accessories of the power plant, are bolted to the frame, being placed with due regard to the centers of gravity and pressure. The usual controlling means are provided and, in addition to these, any of the known stabilizing devices may be embodied in the machine. At rest the planes are vertical, or nearly so, and likewise the shaft driving the propeller 3, which is of a strength, size and pitch such as will enable it to lift the entire weight vertically and withstand safely the stresses. Power is transmitted to the shaft from the turbines through gearing which may be of the single reduction type as illustrated, the turbines rotating in the same direction and neutralizing the gyroscopic moment of the screw. If, instead of one, two propellers are used, either coaxially or otherwise disposed, the motors should revolve in opposite directions. The seats 4, 4, 4 for the operator and passengers are suspended on trunnions 5, 5 on which they can turn through an angle of about 90 degrees, springs and cushions (not shown) being employed to insure and limit their motion through this angle. The ordinary devices for lateral and directional control 6, 6, 7, 7 and 8, 8 are provided with mechanical connections enabling the aviator to actuate them by hand or foot from his seat in any position.

该结构由刚性连接的两个翼面或翼片 1、1 组成。为了小和紧凑，它们的长度和分开的距离可以形成近似正方形。出于同样的目的，尾巴被省略，或者如果使用，它是可伸缩的。为了垂直提升机体，需要非常轻且功率大的原动机，并且特别适合于该目的，我首选使用在我的 1913 年 5 月 6 日的美国专利 1,061,206 中描述的涡轮机，该涡轮机不仅满足这些要求，而且特别适合于在非常高的温度下运行。两个这样的涡轮机（标为 2、2）与动力装置的其他部件和附件一起用螺栓固定在框架上，放置时适当考虑重力中心和压力中心。提供了通常的控制装置，除此之外，任何已知的稳定装置都可以被包含在机器中。在静止时，这些翼面是竖直的，或者几乎是竖直的，驱动螺旋桨 3 的轴也是如此，该轴的强度、尺寸和螺距使得它能够竖直提升整个重量并安全地承受应力。动力通过齿轮装置从涡轮传递到轴，传动装置可以是如图所示的单级减速型，涡轮以相同的方向旋转并抵消螺杆的陀螺力矩。如果不是使用一个螺旋桨，而是使用两个螺旋桨，无论是同轴的还是以其他方式布置的，发动机都应该以相反的方向旋转。用于操作者和乘客的座椅 4、4、4 被悬挂在耳轴 5、5 上，他们可以转过大约 90 度的角度，使用弹簧和垫子(未展示)来确保和限制他们在该角度内的运动。用于横向和方向控制的普通装置 6、6、7、7 和 8、8 设有机械连接，使得飞行员能够在任何位置从他的座位用手或脚操纵它们。

Stated in a few words, the operation is as follows: At the start, sufficient power is turned on by suitable means, also within reach, and the machine rises vertically in the air to the desired height when it is gradually tilted through manipulation of the elevator devices and then proceeds more and more like an aeroplane, the sustaining force of the propeller being replaced by vertical reaction of the foils as the angle of inclination diminishes and horizontal velocity increases. In descending, the forward speed is reduced and the machine righted again, acting as a helicopter with the propeller supporting all the load. The turbine used is of great lightness and activity exceptionally qualified to perform such work for which the present aviation motors are unsuited. It is capable of carrying an extraordinarily great overload and running at excessive speed, and during the starting, landing and other relatively short operations, not only can the necessary power be easily developed, but this can be accomplished without

incurring a serious loss of efficiency. Owing to its extreme simplicity the motive apparatus is very reliable, but should the power give out accidentally, landing can still be effected by volplaning. For this purpose, in addition to wheels 9, 9 and 10, 10, wheels 11, 11 are employed, the latter being mounted on the forward end under the lower plane and so that when the machine rests on level ground, the propeller shaft will have the desired inclination which is deemed best for rising in the manner of an aeroplane. Such a "helicopter-plane," constructed and operated as described, unites the advantages of both types and seems to meet well the requirements of a small, compact, very speedy and safe craft for commercial use.

用几句话陈述，操作如下：开始时，通过合适的装置（也在可触及的范围内）打开足够的动力，当通过操纵升降机装置逐渐倾斜时，机器在空中垂直上升到期望的高度，然后越来越像飞机一样前进，随着倾斜角度减小和水平速度增加，螺旋桨的维持力被翼面的竖直反作用力代替。在下降过程中，前进速度降低，机器再次恢复平衡，就像一架直升机，由螺旋桨支撑全部载荷。所使用的涡轮机非常轻巧，并且非常适合执行当前航空发动机不适合的此类工作。它能够承载非常大的过载并以过高的速度运行，并且在起飞、着陆和其他相对较短的操作期间，不仅可以容易地产生必需的动力，而且可以在不导致严重的效率损失的情况下实现这一点。由于其极其简单的动力装置是非常可靠的，但如果意外失去动力，仍然可以通过滑行实现着陆。为此目的，除了轮子 9、9 和 10、10 之外，还使用了轮子 11、11，后者安装在下翼面下方的前端上，从而当机器停留在接近水平时，螺旋桨轴将具有期望的倾斜度，该倾斜度被认为最适于以飞机的方式升起。这种“直升机飞机”的结构和操作如上所述，结合了两种类型的优点，似乎很好地满足了小型、紧凑、高速和安全的商用飞机的要求。

The abnormal power requirements are met by supplying more of the working fluid to the motors and driving them faster, or running them at about the same speed and increasing the thrust by adjustment of the pitch of the propeller. On account of simplicity and much greater range it is preferable to resort to the first method, in which case the screw should be designed to work most economically in horizontal flight, as its efficiency in the starting and landing operation is of comparatively small importance. Instead of a single large propeller, as described, a number of small ones can be used, when the turbine units may be connected advantageously in stages and the gearing dispensed with. The biplane seems to be particularly well suited for the chief purpose contemplated, but the invention is equally well applicable to monoplanes and other types.

通过向发动机供应更多的工作流体并更快地驱动它们，或者以大约相同的速度运行它们并通过调节螺旋桨的螺距来增加推力，来满足异常的功率需求。考虑到简单性和更大的范围，最好采用第一种方法，在这种情况下，螺杆应该设计成在水平飞行中最经济地工作，因为它在起飞和着陆操作中的效率相对来说不太重要。如上所述，当涡轮单元可以有利地分阶段连接并且省去齿轮传动装置时，可以使用多个小螺旋桨而不是单个大螺旋桨。双翼飞机似乎特别适合预期的主要目的，但是本发明同样适用于单翼飞机和其他类型。

In order to secure the best results I have found it indispensable to depart, in some respects, from the usual design of my turbines and embody in them certain constructive features and means for varying the power developed from the minimum necessary in horizontal flight to an amount exceeding by far their rated performance, as may be required in the operations of ascent and descent, or spurts of speed, or in combating the fury of the elements. Furthermore, I so proportion and coordinate the fluid pressure generator supplying the primary energy, the propelling and the controlling means, that for any

attitude or working condition of the machine the requisite thrust may be almost instantly produced and accurately adjusted.

为了确保最佳结果，我发现在某些方面必须脱离我的涡轮机的通常设计，并在这些涡轮机体现某些结构特征和措施，以改变从水平飞行所需的最小功率发展到超过其额定性能的功率，因为在上升和下降的操作中，或在速度的爆发中，或在对抗恶劣的天气中可能需要这么做。此外，我这样均衡和协调提供主要能量的流体压力发生器、推进装置和控制装置，使得对于机器的任何姿态或工作条件，所需的推力可以几乎立即产生并精确调整。

The understanding of these improvements will be facilitated by reference to Fig. 4 and Fig. 5. In the first named the turbines are intended to operate as rotary engines, expanding the gases in the rotor as well as the inlet nozzle or port 12, the depth of which can be varied by shifting a block 13, fitting freely in a milled channel of the casing, through the medium of lever 14 controlled by the aviator. The orifice for the passage of the elastic fluid is straight or slightly converging, so that a much smaller velocity is obtained than with an expanding nozzle, this enabling the best relation between the peripheral speed of the rotor and that of the fluid to be readily attained. The performance of such an engine at constant pressure of supply is, within wide limits, proportionate to the quantity of the working medium passed through the inlet port and it is practicable to carry, for indefinite intervals of time, an exceedingly great overload, by which I mean up to three or even four times the normal. Exceptional strength and ruggedness of the motors being imperative in view of centrifugal stresses and critical speed, their weight need not be appreciably increased as would be the case in other forms of prime movers in which, as a rule, the weight is in nearly direct proportion to the power developed. To accomplish my purpose I further provide commensurately larger inlet and outlet openings. No serious disadvantage is thereby incurred because windage and other losses are virtually absent and most of the rotary effort is due to the peripheral parts of the discs. As shown in the figure, block 13 is in the position corresponding to minimum effort, the section of the inlet channel being about one-fifth of the whole which is obtained when the block is pulled in its extreme position indicated by the dotted line. Owing to the increase of the coefficient of contraction and counterpressure attendant the enlargement of the inlet, the same should be made of ample section.

参考图 4 和图 5 将有助于理解这些改进。在图 4 中，涡轮机旨在作为旋转发动机运行，使转子中的气体以及入口喷嘴或端口 12 中的气体膨胀，喷嘴深度可以通过移动挡块 13 来改变，挡块 13 被自由地装配在外壳的一个铣削后的通道中，由飞行员控制的杠杆 14 的中介作用进行控制。用于弹性流体通过的孔口是直的或稍微收敛的，从而获得比膨胀喷嘴小得多的速度，这使得能够容易地获得转子的外周速度和流体的外周速度之间的最佳关系。这种发动机的性能在恒定的供应压力下，在很大的范围内，与通过入口的工作介质的量成正比，并且在不确定的时间间隔内，可以承受非常大的过载，我指的是达到正常负载的三倍甚至四倍。考虑到离心应力和临界速度，发动机的特殊强度和耐用性是必要的，它们的重量不需要像其他形式的原动机那样明显增加，在其他形式的原动机中，通常重量几乎与产生的功率成正比。为了实现我的目的，我进一步提供了相匹配的更大的进口和出口。因此不会导致严重的缺陷，因为风阻和其他损失实际上是不存在的，并且大部分旋转力归因于圆盘的外围部分。如图所示，挡块 13 处于对应于最小作用力的位置，入口通道的截面大约是挡块被拉到由虚线所示的极限位置时所获得的整个截面的五分之一。由于缩流系数和背压力的增加，入口的扩大随之而来，入口应该有足够的截面。

Figure 5 shows a different means for attaining the same purpose. In this case the motors operate like true turbines, the working fluid being fully expanded, or nearly so, through divergent exchangeable nozzles as 15, having a throat of sufficient section for the passage of fluid required during maximum performance. The exhaust opening is also correspondingly enlarged, though not necessarily to the extent indicated in Figure 4. The power is varied by means of a throttle valve 16, as used in automobiles, located in the conduit supplying the air and carbureted fuel to the fluid pressure generator and mechanically connected to the controlling lever 14. This apparatus is of a capacity adequate to the maximum demand by which I do not mean that it is necessarily much larger than required for normal performances, but is merely designed to supply the working fluid or, broadly stated, energy—whenever desired, at a rate greatly exceeding the normal. In Figure 3 this apparatus is diagrammatically indicated by 17, and may be any one of a number of well-known types, producing pressure by internal combustion of a suitable fuel or by external firing of a steam boiler. In the latter case, with constant pressure, the arrangement shown in Figure 4 is best to employ, while the plan illustrated in Figure 5 can be used to advantage when both pressure and quantity of fluid are varied.

图 5 展示了实现相同目的的一个不同方式。在这种情况下，发动机像真正的涡轮机一样运行，工作流体通过发散的可更换喷嘴 15 完全膨胀，或者几乎完全膨胀，喷嘴 15 具有一个拥有足够截面的喉部，用于在最大性能期间让所需的流体通过。排气口尽管不一定扩大到图 4 所示的程度，也相应地扩大。通过一个节流阀 16 改变功率，该节流阀就如在汽车中使用的，节流阀 16 位于向流体压力发生器供应空气和汽化燃料的导管中，并且机械地连接到控制杠杆 14。这种设备的容量足以满足最大需求，我的意思不是说它必须比正常性能所需的容量大得多，而仅仅是设计成在任何需要的时候以大大超过正常的速率提供工作流体或广义上的能量。在图 3 中，该装置由 17 示意性地表示，并且可以是多种众所周知的类型中的任何一种，通过适合燃料的内部燃烧或者通过蒸汽锅炉的外部点火来产生压力。在后一种情况下，在压力恒定的情况下，最好采用图 4 所示的布置，而当压力和流体量都变化时，可以有利地使用图 5 所示的方案。

In operation for vertical ascent, the machine being in the attitude of Figure 1, the aviator will push forward lever 14 and supply sufficient primary energy to the motors for lifting the machine with the desired velocity. When the objective elevation is reached rudders 7, 7 are manipulated to incline the machine at a certain angle, the aviator simultaneously applying more pressure to the lever and augmenting the fluid supply to the motors, thereby increasing the propeller thrust in the vertical direction so as to prevent the machine from descending. He continues these operations always coordinating the thrust developed with the changes in attitude of the machine until a certain angle of inclination is attained and the machine is supported chiefly by reaction of the planes. At this stage he begins to reduce the pressure on the lever and supply of working fluid simultaneously decreasing the angle of inclination thus finally effecting, by insensible steps, horizontal flight.

在垂直上升的操作中，机器处于图 1 的姿态，飞行员将向前推动杠杆 14，并向发动机提供足够的初级能量，用于以期望的速度提升机器。当达到目标高度时，操纵方向舵 7、7 以使得机器倾斜某一角度，飞行员同时向杠杆施加更大的压力并增加发动机的流体供应，从而增加垂直方向上的螺旋桨推力，来防止机器下降。他继续这些操作，总是协调推力随着机器姿态的变化而变化，直到达到一定的倾斜角度，机器主要由翼面的反作用力支撑。在这个阶段，他开始减少杠杆上的压力和工作流体的供应，同时减少倾斜角度，从而最终通过无意识的步骤实现水平飞行。

It should be understood that descent and alighting, as well as rising in the manner of a true aeroplane may be accomplished as usual. In such case the motors will be operated at their normal rated capacity. However, when excessive speed becomes necessary, the effort of the motors may be instantly and greatly augmented by merely manipulating block 13 or valve 16 as described.

应该理解的是，下降和降落，以及以真正飞机的方式上升，可以照常完成。在这种情况下，发动机将以其正常额定能力运行。然而，当过大的速度变得必要时，仅通过如上所述操纵挡块 13 或阀门 16，发动机的作用力就可以立即大大增加。

Whenever it is desired to descend vertically, the aviator will reverse the operations as applying to substantial vertical ascent, which is to say, bring the machine gradually into starting attitude, at the same time increasing the supply of fluid to the motors and the vertical component of the propeller thrust, while reducing the horizontal. Finally, he will steadily reduce the fluid supply and the vertical thrust so as to descend to the landing place at a very low, safe velocity.

每当希望垂直下降时，飞行员将逆转应用于基本垂直上升的操作，也就是说，使机器逐渐进入起飞姿态，同时增加发动机的流体供应和螺旋桨推力的垂直分量，同时减小水平方向分量。最后，他将稳定地减少流体供应和垂直推力，以便以非常低的安全速度下降到着陆点。

In the preceding I have described a flying machine characterized by a number of novel constructive and operative features and well suited for meeting a pressing necessity in the present state of the art. The chief improvements consist in first, adapting my turbine motor for excessive overload without appreciable increase of its weight, second, providing large variable inlet ports and corresponding exhaust openings, with the object of meeting the abnormal power requirements in the starting, landing and other short operations, and still preserving a high efficiency in horizontal flight; third, combining with the turbine a fluid pressure generator of adequate capacity with means for control and, fourth, embodying these and other features in a suitable structure improved in various details. These may be greatly varied and I wish it to be understood that I do not limit myself to the precise arrangements illustrated and described.

在前面，我已经描述了一种飞行器，其特点是具有许多新颖的结构和操作特征，并且非常适合满足当前技术水平的迫切需要。主要的改进包括：第一，在不明显增加重量的情况下，使我的涡轮发动机适应极度过载；第二，提供大的可变的进气口和相应的排气口，目的是满足起飞、着陆和其他短距离操作中的异常功率要求，并仍然保持水平飞行的高效率；第三，将带有控制装置的足够容量的流体压力发生器与涡轮机结合；第四，在各种细节上改进后的适合结构中所体现的这些和其他特征。这些可能有很大的变化，我希望要被理解的是，我不将自己限制在所示和描述的精确布置中。

I claim as my invention:

我主张我的发明是:

1. In an aeroplane adapted for vertical and horizontal propulsion and change from one to the other attitude, the combination of means for tilting the machine in the air, a fluid pressure generator of a capacity several times greater than normally required in horizontal flight, a motor capable of carrying

overloads adequate for support in all attitudes, and means for controlling the supply of the fluid to the motor in accordance with the inclination of the machine.

1、在适于垂直和水平推进并从一个姿态改变到另一个姿态的一架飞机中，存在一个组合，包括：用于在空中倾斜机器的措施；容量比水平飞行中通常所需的容量大几倍的一个流体压力发生器；一种发动机，能够承载足够的负载，以支持各种姿态；以及根据机器的倾斜来控制流体供应到发动机的措施。

2. In an aeroplane adapted for vertical and horizontal propulsion and change from one to the other attitude, the combination with means for tilting the machine in the air and a system producing thrust approximately parallel to the principal axis of the same and including a fluid pressure generator having a capacity several times greater than normally required in horizontal flight, a motor capable of carrying over-loads adequate for support in all altitudes, and means for controlling the supply of the fluid to the motor in accordance with the inclination of the machine.

2、在适于垂直和水平推进并从一个姿态改变到另一个姿态的飞机中，存在一个组合，包括用于使机器在空中倾斜的装置和产生近似平行于其主轴的推力的系统，该系统包括一个流体压力发生器，其容量比水平飞行中通常所需的容量大几倍；还有一种发动机，能够承载足够的负载，以支持各种姿态；以及根据机器的倾斜来控制供应到发动机的流体的措施。

3. In an aeroplane adapted for vertical and horizontal propulsion and change from one to the other attitude, the combination of means for tilting the machine in the air, a fluid pressure generator capable of supplying fluid at a rate several times greater than required for horizontal flight, a prime mover consisting of a rotor of plane spaced discs with central openings and an enclosing casing with inlet and outlet orifices of a section much greater than required for normal performances respectively at the periphery and center of the same, and means for controlling the supply of the fluid to the motor in accordance with the inclination of the machine.

3、在适于垂直和水平推进并从一个姿态改变到另一个姿态的飞机中，存在一个组合，包括：用于使机器在空中倾斜的装置；能够以比水平飞行所需的供应速度大几倍的速度供应流体的流体压力发生器；由具有中心开口的平面间隔圆盘的转子和具有入口孔和出口孔的封闭壳体组成的原动机，所述入口孔和出口孔的截面分别在原动机的外周和中心，并且比正常性能所需的截面大得多；以及根据机器的倾斜来控制供应到发动机的流体的措施。

4. In an aeroplane adapted for vertical and horizontal propulsion and change from one to the other attitude, the combination of means for tilting the machine in the air, a thrust producing system having its principal energy producing elements designed for normal load in horizontal flight but capable of carrying over-loads adequate for support of the aeroplane in all attitudes, and means for controlling the energy produced in said system in accordance with the inclination of the machine.

4、在适于垂直和水平推进以及从一个姿态改变到另一个姿态的飞机中，存在一个组合，包括：用于在空中倾斜机器的装置；推力产生系统，其主要能量产生组件被设计用于水平飞行中的正常载荷，但能够承载足够的过载，来支撑所有姿态下的飞机；以及根据机器的倾斜来控制流体供应到发动机的措施。

5. In a flying machine of the kind described in combination with means for vertical and lateral control of two wheel bases at right angles to one another as set forth.

5、在一种飞行器中，结合所描述的方法，对两个彼此成直角的轮架进行垂直控制和横向控制，如上所述。

6. In a flying machine of the kind described in combination with means for vertical and lateral control of two wheel bases at right angles to one another and having one or more wheels common to both.

6、在一种飞行器中，结合所描述的方法，对两个彼此成直角的轮架进行垂直控制和横向控制，这两个轮架有一个或者多个共用轮。

In testimony whereof I hereunto affix my signature.

我在此签名为证。

NIKOLA TESLA.

尼古拉·特斯拉

Jan. 3, 1928.

1,655,114

N. TESLA

APPARATUS FOR AERIAL TRANSPORTATION

Filed Oct. 4, 1927

2 Sheets-Sheet 1

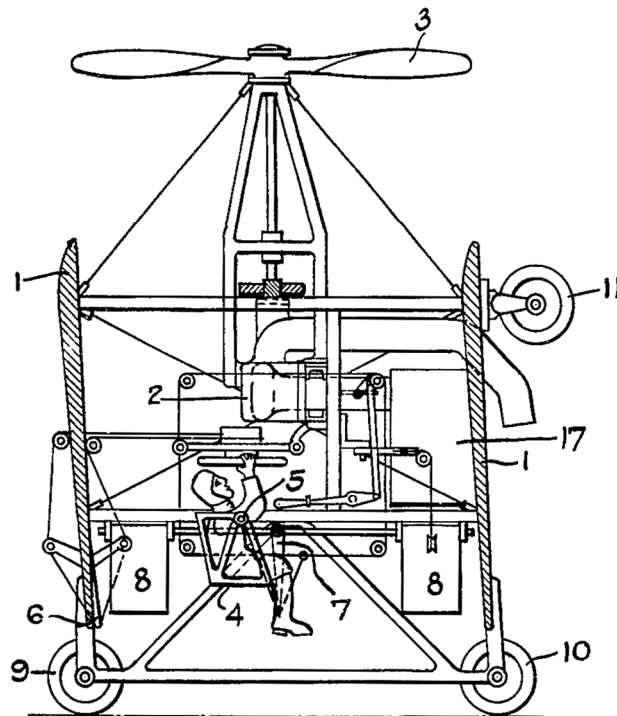


FIG. 1.

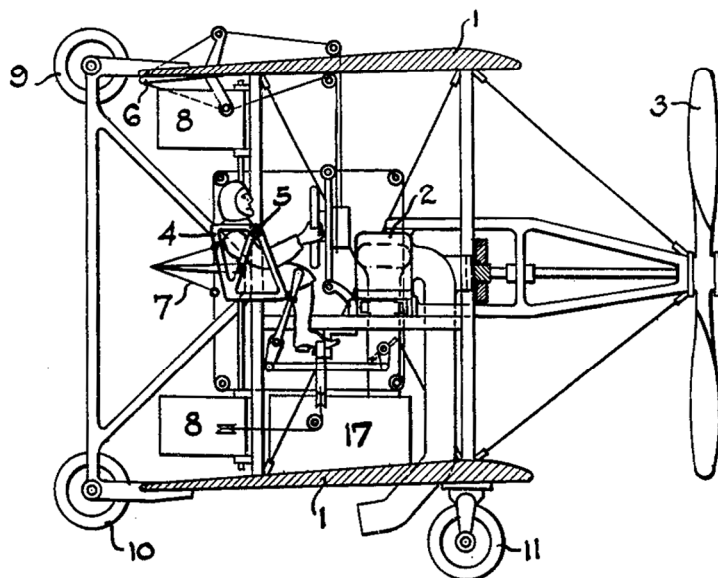


FIG. 2.

INVENTOR.

NIKOLA TESLA.

BY *John P. Jacob*

ATTORNEY.

Jan. 3, 1928.

1,655,114

N. TESLA

APPARATUS FOR AERIAL TRANSPORTATION

Filed Oct. 4, 1927

2 Sheets-Sheet 2

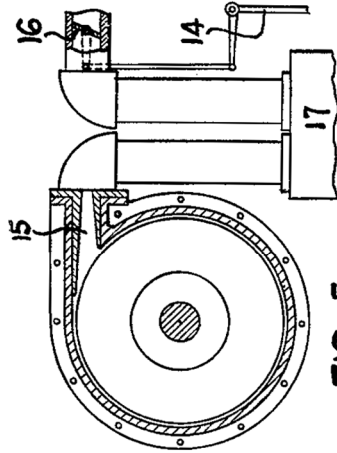


FIG. 5.

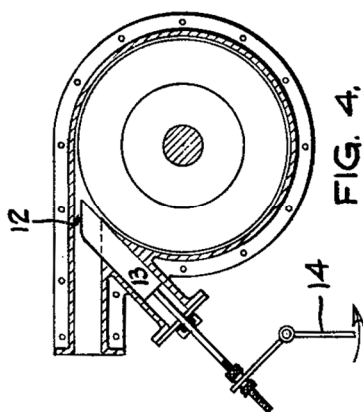


FIG. 4.

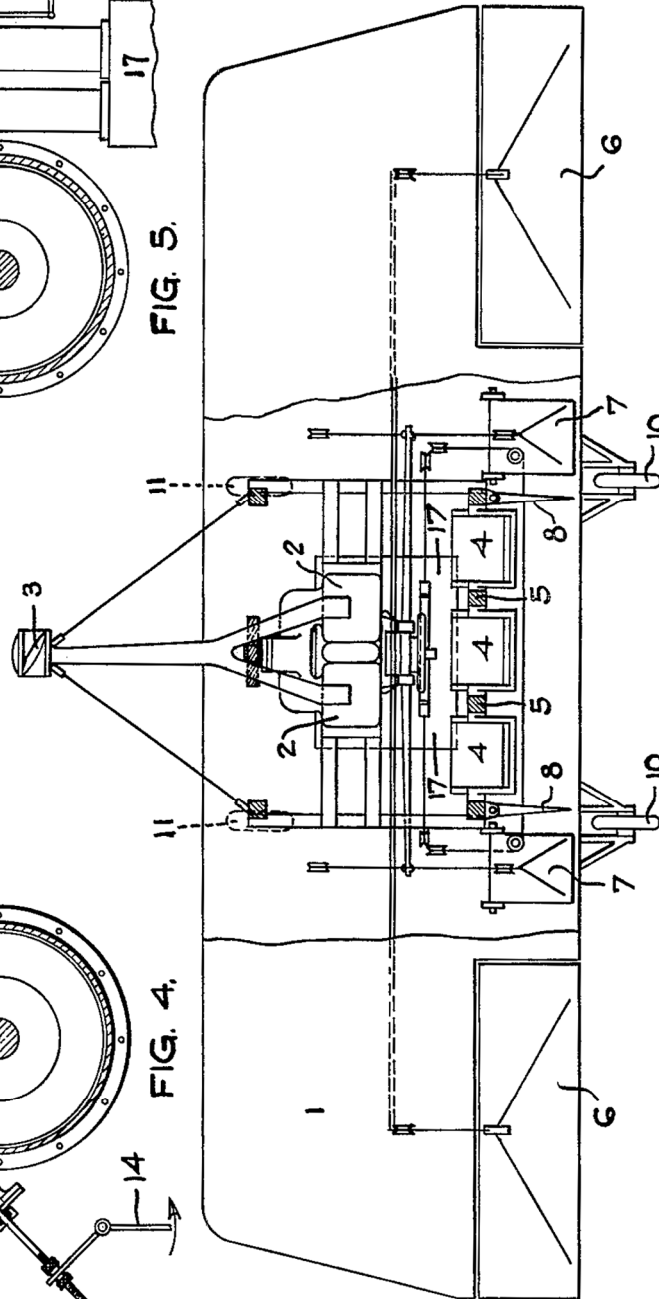


FIG. 3.

INVENTOR.

NIKOLA TESLA.

BY

John P. Tarbo

ATTORNEY.

LIGHTNING-PROTECTOR.

避雷装置

NIKOLA TESLA, OF NEW YORK, N. Y.

纽约州纽约市的尼古拉·特斯拉

1,266,175. Specification of Letters Patent. Patented May 14, 1918.

Application filed May 6, 1916. Serial No. 95,830.

专利证书说明书第 1,266,175 号。在 1918 年 5 月 14 日被授予专利。

申请于 1916 年 5 月 6 日。序列号为 95,830。

To all whom it may concern:

致所有相关人士：

Be it known that I, NIKOLA TESLA, a citizen of the United States, residing at New York, in the county and State of New York, have invented certain new and useful Improvements in Lightning-Protectors, of which the following is a full, clear, and exact description.

众所周知，我、尼古拉·特斯拉，一位美国公民，居住在纽约州纽约郡纽约市，在避雷装置方面已经发明了某些新的和有用的改进，以下是该发明的一个完整的、清晰的和准确的描述。

The object of the present invention is to provide lightning protectors of a novel and improved design strictly in conformity with the true character of the phenomenon, more efficient in action, and far more dependable in safe-guarding life and property, than those heretofore employed.

本发明的目的是提供一种新颖的和改进设计后的避雷装置，它严格地符合这种现象的真实特征，与以往使用的避雷装置相比，作用更有效，并在保护生命和财产方面更可靠得多。

To an understanding of the nature of my invention and its basic distinction from the lightning rods of common use, it is necessary briefly to explain the principles upon which my protector is designed as contrasted with those underlying the now-prevailing type of lightning rod.

为了理解我的发明的本质以及它与通常使用的避雷针的基本区别，有必要简要解释一下我的避雷装置的设计原理与现在流行的避雷针类型的原理对比。

Since the introduction of the lightning rod by Benjamin Franklin in the latter part of the eighteenth century, its adoption as a means of protection against destructive atmospheric discharges has been practically universal. Its efficiency, to a certain degree, has been unquestionably established through statistical records but there is generally prevalent, nevertheless, a singular theoretical fallacy as to its operation, and its construction is radically defective in one feature, namely its typical pointed terminal. In my lightning protector I avoid points, and use an entirely different type of terminal.

自从本杰明·富兰克林在 18 世纪后期引入避雷针以来，避雷针作为一种免受破坏性大气放电破坏的保护手段几乎已经被普遍采用。它的效率，在一定程度上，已经通过统计记录毫无疑问地建立起来，但是仍然普遍存在一个关于其运行的单一理论谬误，并且其构造在一个特征上有根本缺陷，即其典型的尖端末端。在我的避雷装置中，我避开了尖端末端，使用了完全不同类型的终端。

According to the prevailing opinion, the virtue of the Franklin type of lightning rod is largely based on the property of points or sharp edges to give off electricity into the air. As shown by Coulomb, the quantity of electricity per unit area, designated by him “electrical density” increases as the radius of curvature of the surface is reduced. Subsequently it was proved, by mathematical analysis, that the accumulated charge created an outward normal force equal to 2π times the square of the density, and experiment has demonstrated that when the latter exceeds approximately 20 C. G. S. units, a streamer or corona is formed. From these observations and deductions it is obvious that such may happen at a comparatively low pressure if the conductor is of extremely small radius, or pointed, and it is pursuant to a misapplication of these, and other, truths that the commercial lightning rod of today is made very slender and pointed. My invention, on the contrary, while taking cognizance of these truths, correctly applies them in the provision of a lightning protector that distinctively affords an elevated terminal having its outer conducting boundaries arranged on surfaces of large radii of curvature on two dimensions. The principles which underlie my invention and correct application of which dictate the form and manner of installation of my protector, I will now explain in contrast with the conventional pointed lightning rod.

根据流行的观点，富兰克林式避雷针的优点很大程度上是基于尖端或锋利边缘将电释放到空气中的特性。如库仑所示的那样，单位面积上的电量，被他称为“电密度”，随着表面曲率半径的减小而增加。随后，通过数学分析证明，积累的电荷产生了一个向外的法向力，这个力等于 2π 乘以密度的平方，并且实验证明，当密度超过大约 20 电磁单位时，就会形成流光或电晕。从这些观察和推论可以明显看出，如果导体的半径极小或很尖，则可能在相对较低的电压力下发生这种情况，并且根据对这些事实和其他事实的误用，今天的商业避雷针被做的非常细长和非常尖。相反，我的发明在认识到这些事实的同时，正确地将它们应用于提供一种避雷装置，该避雷装置独特地提供了一种高架终端，其外部导电边界设置在二维的大曲率半径的表面上。我的发明的基本原理及其正确应用决定了我的避雷器的安装形式和方式，现在我将对照传统的尖头避雷针进行解释。

In permitting leakage into the air, the needle-shaped lightning-rod is popularly believed to perform two functions: one to drain the ground of its negative electricity, the other to neutralize the positive of the clouds. To some degree it does both. But a systematic study of electrical disturbances in the earth has made it palpably evident that the action of Franklin's conductor, as so commonly interpreted, is chiefly illusory. Actual measurement proves the quantity of electricity escaping even from many points, to be entirely insignificant when compared with that induced within a considerable terrestrial area, and of no moment whatever in the process of dissipation. But it is true that the negatively charged air in the vicinity of the rod, rendered conductive through the influence of the same, facilitates the passage of the bolt. Therefore it increases the probability of a lighting discharge in its vicinity. The fundamental facts underlying this type of lightning-rod are: First, it attracts lightning, so that it will be struck oftener than would be the building if it were not present; second, it renders harmless most, but not all, of the discharges which it receives; third, by rendering the air conductive, and for other reasons, it is sometimes

the cause of damage to neighboring objects; and fourth, on the whole, its power of preventing injury predominates, more or less, over the hazards it invites.

在允许泄漏到空气中时，针形避雷针通常被认为执行两个功能：一个是消耗地面的负电，另一个是中和云中的正电。在某种程度上，两者都有。但是对地球上的电扰动的一个系统研究已经清楚地表明，富兰克林的导体的作用，比如如此普遍的解释，多半是虚幻的。实际测量证明，即使是从尖点漏出的电量，与在相当大的陆地范围内感应出的电量相比，也是微不足道的，没有任何时刻是在耗散过程中。但是确实，在杆附近的带负电的空气，通过杆的影响变得导电，促进了闪电的通过。因此，杆增加了在它附近的发光放电的可能性。这种避雷针的基本事实是：首先，它会吸引闪电，所以它会比没有安装避雷针的建筑物更容易被闪电击中；第二，对于它接收到的放电，在大多数情况下它表现得无害，但不是在所有情况下都是这样；第三，通过使空气导电，以及由于其他原因，它有时是对邻近物体造成损害的原因；第四，总的来说，它防止伤害的能力或多或少地战胜了它带来的危险。

My protector, by contrast, is founded on principles diametrically opposite. Its terminal has a large surface. It secures a very low density and preserves the insulating qualities of the ambient medium, thereby minimizing leakage, and in thus acting as a quasi-repellent to increase enormously the safety factor.

相比之下，我的避雷器建立在截然相反的原理上。它的终端有一个大的表面。它确保了一个非常低的电密度，并保持了环境介质的绝缘品质，从而最大限度地减少了漏电，并因此作为一种准排斥机制极大地增加了安全系数。

For the best and most economical installation of protective devices according to my invention, those factors and phenomena that dictate size, number of protectors and physical qualities of the apparatus must be grasped by the installing engineer, and preliminary, for full understanding of the principles of my invention, these should be briefly explained.

为了最好和最经济地安装根据本发明的保护装置，安装工程师必须掌握那些决定装置尺寸、避雷器的数量和物理品质的因素和现象，并且是初步的，为了充分理解本发明的原理，应该简要地解释这些因素和现象。

Economical installation, of course, demands that the protective capability of any given equipment be not needlessly greater than is required to meet the maximum expectancies under the conditions surrounding the particular building to be protected, and these depend, partially, as I shall show, upon the character of the landscape proximate to the building site.

当然，经济的安装会要求任何给定设备的保护能力不会不必要地大于在要保护的特定建筑物周围的条件下满足所需的最大预期，并且正如我将要说明的，这些保护能力部分地取决于建筑地点附近的地形特征。

In the drawings, Figures 1 to 4 inclusive, are diagrams requisite to illustration of the facts and conditions relevant to the determination of specific installations of my invention, and Figs. 5 to 8 illustrate construction and application of the protectors. Specifically:

在附图中,图 1 至图 4 是用来说明与确定本发明的具体装置相关的事实和条件所必需的示意图,图 5 至图 8 说明了避雷器的结构和应用。具体来说:

Fig. 1 is a landscape suited for purpose of explanation; Figs. 2, 3 and 4 are theoretical diagrams; Figs. 5 and 6 illustrate forms of improved protectors; and Figs. 7 and 8 show buildings equipped with the same.

图 1 是适于解释目的的地形;图 2、3 和 4 是理论示意图;图 5 和 6 展示了改进的避雷器的形式;图 7 和图 8 展示了配备有该装置的建筑物。

In Fig. 1, 1 represents Lord Kelvin's "reduced" area of the region, which is virtually part of the extended unruffled ocean-surface. (See "Papers on Electrostatics and Magnetism" by Sir William Thomson). Under ordinary weather conditions, when the sky is clear, the total amount of electricity distributed over the land is nearly the same as that which would be contained within its horizontal projection. But in times of storm, owing to the inductive action of the clouds, an immense charge may be accumulated in the locality, the density being greatest at the most elevated portions of the ground. Assuming this, under the conditions existing at any moment, let another spherical surface 2, concentric with the earth, be drawn—which may be called "electrical niveau" —such that the quantities stored over and under it are equal. In other words, their algebraic sum, taken relatively to the imaginary surface, in the positive and negative sense, is nil. Objects above the "niveau" are exposed to ever so much more risk than those below. Thus, a building at 3, on a site of excessive density, is apt to be so hit sooner or later, while one in a depression 4, where the charge per unit area is very small, is almost entirely safe. It follows that the one building 3 requires more extensive equipment than does the other. In both instances, however, the probability of being struck is decreased by the presence of my protector, whereas it would be increased by the presence of the Franklin rod, for reasons that I will now explain.

在图 1 中,1 代表开尔文勋爵的该区域的“缩小后”的面积,它实际上是延伸的平静海洋表面的一部分。(见威廉·汤姆孙爵士的《关于静电学和磁学的论文》)。在正常的天气条件下,当天空晴朗时,分布在地面上的总电量几乎与它的水平投影所包含的电量相同。但是在暴风雨的时候,由于云的感应作用,一个巨大的电荷可能会在这个地点积累,电荷密度在地面的最高部分最大。假设这一点,在任何时刻都存在的条件下,画出另一个与地球同心的球面 2——这可以被称为“电水平”——使得在它上面和下面电荷储量相等。换句话说,相对于虚拟曲面,在正负意义上,它们的代数和是零。高于“水平”的物体比低于“水平”的物体暴露在更大的风险中。因此,位于 3 的建筑物,在电密度过大的地点,迟早会被击中,而位于 4 洼地的建筑物,单位面积的电荷很小,几乎完全安全。由此可见,一个建筑物 3 比另一个建筑物需要更多的设备。然而,在这两种情况下,我的避雷器的存在减少了被击中的可能性,而富兰克林杆的存在会增加被击中的可能性,原因我现在解释。

An understanding of but part of the truths relative to electrical discharges, and their misapplication due to the want of fuller appreciation has doubtless been responsible for the Franklin lightning rod taking its conventional pointed form, but theoretical considerations, and the important discoveries that have been made in the course of investigations with a wireless transmitter of great activity by which arcs of a volume and tension comparable to those occurring in nature were obtained ("Problems of Increasing Human Energy" Century Magazine June 1900 and Patents 645,576, 649,621, 787,412 and 1,119,732) at once establish the fallacy of the hitherto prevailing notion on which the Franklin type of rod is based, show the distinctive novelty of my lightning protector, and guide the constructor in the use of my

invention.

对与放电有关的真理的部分理解，以及由于缺乏更全面的理解而导致的误用，无疑是富兰克林避雷针采用其传统的尖头形式的原因，然而理论上的考虑，以及在研究无线电发射机的过程中所取得的重要发现，获得了与自然界中发生的电弧相当的电量和电压(《增长中的人类能量的问题》世纪杂志 1900 年 6 月和专利 645,576、649,621、787,412 和 1,119,732)，上述的部分理解和误用立刻建立了迄今为止富兰克林类型避雷针所基于的流行观念的谬误，也展示出我的避雷装置的独特的新颖性，并能指导施工人员使用我的发明。

In Fig. 2, 5 is a small sphere in contact so with a large one, 6, partly shown. It can be proved by the theory of electric images that when the two bodies are charged the mean density on the small one will be only $\pi^2/6 = 1.64493$ times greater than that on the other, (See "Electricity and Magnetism" by Clerk Maxwell). In Fig. 3, the two spheres 7 and 8 are placed some distance apart and connected through a thin wire 9. This system having been excited as before, the density on the small sphere is likely to be many times that on the large one. Since both are at the same potential it follows directly that the densities on them will be inversely as their radii of curvature. If the density of 7 be designated as d and the radius r , then the charge $q = 4\pi r^2 d$, the potential $p = 4\pi r d$ and the outward force, normal to the surface, $f = 2\pi d^2$. As before stated, when d surpasses 20 C. G. S. units, the force f becomes sufficiently intense to break down the dielectric and a streamer or corona appears. In this case $p = 80\pi$. Hence, with a sphere of one centimeter radius disruption would take place at a potential $p = 80\pi = 251.328$ E. S. units, or 75,398.4 volts. In reality, the discharge occurs at a lower pressure as a consequence of uneven distribution on the small sphere, the density being greatest on the side turned away from the large one. In this respect the behavior of a pointed conductor is just the reverse. Theoretically, it might erroneously be inferred from the preceding, that sharp projections would permit electricity to escape at the lowest potentials, but this does not follow. The reason will be clear from an inspection of Fig. 4, in which such a needle-shaped conductor 10, is illustrated, a minute portion of its tapering end being marked 11. Were this portion removed from the large part 10 and electrically connected with the same through an infinitely thin wire, the charge would be given off readily. But the presence of 10 has the effect of reducing the capacity of 11, so that a much higher pressure is required to raise the density to the critical value. The larger the body, the more pronounced is this influence, which is also dependent on configuration, and is maximum for a sphere. When the same is of considerable size it takes a much greater electromotive force than under ordinary circumstances to produce streamers from the point. To explain this apparent anomaly attention is called to Fig. 3. If the radii of the two spheres, 7 and 8, be designated r and R respectively, their charges q and Q and the distance between their centers D , the potential at 7, due to Q is Q/D . But 7, owing to the metallic connection 9, is at the potential $Q/R = q/r$. When D is comparable to R , the medium surrounding the small sphere will ordinarily be at a potential not much different from that of the latter and millions of volts may have to be applied before streamers issue, even from sharp protruding edges. It is important to bear this in mind, for the earth is but a vast conducting globe. It follows that a pointed lightning-rod must be run far above ground in order to operate at all, and from the foregoing it will be apparent that the pointing of the end, for supposed emissive effect, is in part neutralized by the increasing size below the extreme end, and the larger the rod, for reduction of electrode resistance, the more pronounced in this counter-influence. For these reasons it is important to bear in mind that sufficient thickness of the rod for very low electrode-resistance is rather incompatible with the high emissive capability sought in the needle-like Franklin-rod, but, as hereinafter set forth, it is wholly desirable in the use of my invention, wherein the

terminal construction is intended for suppression of charge-emission rather than to foster it.

在图 2 中, 5 是与大球体 6 接触的小球体, 部分展示。电像理论可以证明, 当两个物体都带电时, 小的一个物体上的平均电密度只会比另一个物体上的平均电密度大出 $\pi^2/6 = 1.64493$ 倍, (见克拉克·麦克斯韦的《电与磁》)。在图 3 中, 两个球体 7 和 8 相隔一定距离放置, 并通过一条细导线 9 连接。这个系统像以前一样被激发, 小球上的电密度可能是大球上的许多倍。因为两者都处于相同的电位, 所以可以直接得出结论, 它们的电密度与曲率半径成反比。如果 7 的电密度为 d , 半径为 r , 那么电荷 $q = 4\pi r^2 d$, 电势 $p = 4\pi r d$, 垂直于表面的力 $f = 2\pi d^2$ 。如前所述, 当 d 超过 20 电磁单位时, 力 f 变得足够强, 足以击穿电介质, 会出现一个流光或电晕。这种情况下, $p = 80\pi r$ 。因此, 对于一个半径为 1 厘米的球体, 在 $p = 80\pi = 251.328$ 静电单位或 75,398.4 伏特的电势下会发生破坏性放电。事实上, 由于小球体上的不均匀分布, 放电发生在一个较低的电压下, 电密度在远离大球体的一侧最大。在这方面, 尖头导体的行为正好相反。从理论上讲, 从前面的论述中可能会错误地推断出, 尖锐的突出会使电在最低电位下逃逸, 但这并不成立。从图 4 中可以清楚地看出原因, 在图 4 中示出了这种针状导体 10, 其锥形端的微小部分被标记为 11。如果将这部分从大部件 10 上取下, 并通过一根无限细的导线与大部件 10 电连接, 电荷将很容易释放。但是 10 的存在具有降低 11 的容量的效果, 因此需要高得多的电压力来将电密度提高到临界值。物体越大, 这种影响越明显, 这也取决于形状, 对于球体来说这种影响是最大的。当球体是相当大的尺寸, 它需要的电动势比一般情况下产生流光所需的电动势更大。为了解释这种明显的异常, 请注意图 3。如果两个球体 7 和 8 的半径分别被指定为 r 和 R , 它们的电荷 q 和 Q 以及它们的中心之间的距离 D , 由于 Q 为 Q/D , 7 处的电势是 Q/D 。但由于金属连接 9, 所以 7 处的电势为 $Q/R = q/r$ 。当 D 与 R 相当时, 小球体周围的介质通常处于与后者相差不大的电位, 并且在流光发出之前, 可能必须施加数百万伏的电压, 即使是从尖锐的突出边缘发出也是如此。记住这一点很重要, 因为地球只是一个巨大的导电球体。接下来, 一根尖头避雷针必须在地面以上很远的地方才能完全运行, 从上述内容可以明显看出, 由于假定的发射效应, 末端的尖点部分地被极端处以下增加的尺寸所中和, 由于降低电极电阻, 避雷针越大, 这种反作用影响力越明显。由于这些原因, 重要的是要记住, 为了得到非常低电极电阻而采用的足够粗度的避雷针与富兰克林的针状避雷针寻求的高发射能力是相当不相容的, 但是, 如下文所述, 在使用我的发明时, 这是完全需要的, 其中终端结构旨在抑制电荷发射而不是促进电荷发射。

The notion that Franklin's device would be effective in dissipating terrestrial charges may be traced to early experiments with static frictional machines, when a needle was found capable of quickly draining an insulated electrified body. But the inapplicability of this fact to the conditions of lightning protection will be evident from examination of the simple theoretical principles involved, which at the same time substantiate the desirability of establishing protection by avoiding such drainage. The density at the pointed end f should be inversely as the radius of curvature of the surface, but such a condition is unrealizable. Suppose Fig. 4 to represent a conductor of radius 100 times that of the needle; then, although its surface per unit length is greater in the same ratio, the capacity is only double. Thus, while twice the quantity of electricity is stored, the density on the rod is but one-fiftieth of that on the needle, from which it follows that the latter is far more efficient. But the emissive power of any such conductor is circumscribed. Imagine that the "pointed" (in reality blunt or rounded) end be continuously reduced in size so as to approximate the ideal more and more. During the process of reduction, the density will be increasing as the radius of curvature acts smaller, but in a proportion distinctly less than linear; on the other hand, the area of the extreme end, that is, the section through which the charge passes out into the air, will be diminishing as the square of the radius. This relation alone imposes a

definite limit to the performance of a pointed conductor, and it should be noticed that the electrode resistance would be augmented at the same time. Furthermore, the efficacy of the rod is much impaired through potential due to the charge of the ground, as has been indicated with reference to Fig. 3. Practical estimates of the electrical quantities concerned in natural disturbances show, moreover, how absolutely impossible are the functions attributed to the pointed lightning conductor. A single cloud may contain 2×10^{12} C. G. S. units, or more, inducing in the earth an equivalent amount, which a number of lightning rods could not neutralize in many years. Particularly to instance conditions that may have to be met, reference is made to the Electrical World of March 5, 1904, wherein it appears that upon one occasion approximately 12,000 strokes occurred within two hours within a radius of less than 50 kilometers from the place of observation.

富兰克林的装置可以有效地消除地面电荷的想法可以追溯到早期的静摩擦机器实验,当时人们发现针能够迅速吸引被绝缘的带电体。但是,通过检查所涉及的简单理论原理,这一事实对防雷条件的不适用性将是显而易见的,同时证实了通过避免这种引流来建立保护的可取性。尖端 f 处的电密度应与曲面的曲率半径成反比,但这种情况是不现实的。假设图 4 表示半径为针的半径 100 倍的导体;那么,虽然它的单位长度的表面积在相同的比率下更大,但容量却只有两倍。因此,虽然储存了两倍的电量,但避雷针上的电密度只有针上电密度的五十分之一,由此可以得出结论,后者的效率要高得多。但是任何这种导体的发射功率都是有限的。想象一下“尖的”(实际上是钝的或圆的)一端的尺寸不断减小,以便越来越接近理想状态。在减小的过程中,电密度将随着曲率半径的减小而增加,但增加的比例明显小于线性;另一方面,极端处的面积,即电荷进入空气的截面,将随着半径的平方而减小。仅这一关系就对尖头导体的性能施加了明确的限制,而且应该注意到,电极电阻同时也会增大。此外,如参考图 3 所指出的,由于大地的电荷,避雷针的功效通过电势被大大削弱。此外,对与自然扰动有关的电量的实际估计表明,归因于尖端避雷针的功能是多么绝对不可能。一朵云可能含有 2×10^{12} 电磁单位或者更多,可以在地球上感应出等量的电荷,这是许多年来许多避雷针都无法中和的电荷量。特别是对于可能必须满足的实例条件,参考了在 1904 年 3 月 5 日出版的《电气世界》,其中似乎有一次在距观察地点不到 50 公里的半径范围内,两小时内发生了大约 12,000 次雷电闪光。

But although the pointed lightning-rod is quite ineffective in the one respect noted, it has the property of attracting lightning to a high degree, firstly on account of its shape and secondly because it ionizes and renders conductive the surrounding air. This has been unquestionably established in long continued tests with the wireless transmitter above-mentioned, and in this feature lies the chief disadvantage of the Franklin type of apparatus.

但是,尽管尖头避雷针在上述一个方面相当无效,但它具有高度吸引闪电的特性,首先是因为它的形状,其次是因为它使周围的空气电离并使其具有导电性。这一点已经在对上文提到的无线发射机的长期持续测试中毫无疑问地得到了证实,并且这一特征是富兰克林型设备的主要缺点。

All of the foregoing serves to show that since it is utterly impracticable to effect an equalization of charges emissively through pointed lightning-rods under the conditions presented by the vast forces of nature great improvement lies in the attainment of a minimized probability of lightning stroke to the area to be protected coupled with adequate conductivity to render harmless those strokes that may, notwithstanding, occur.

所有上述内容都表明，在自然的巨大力量所呈现的条件下，由于通过尖头避雷针发射地实现电荷的均衡是完全不切实际的，所以很大的改进在于将要保护的区域的雷击可能性降到最低，尽管如此，这还要与足够的导电性结合以使可能发生的雷击无害。

Furthermore, a correct application of the truths that have thus been explained with reference to the familiar pointed type of lightning-rod not only substantiates the theoretical propriety of the form in which I develop my improved lightning protector, but will lead the installing engineer properly to take cognizance of those conditions due to location of the building, with respect to surrounding earth formations and other buildings, probabilities of maximum potential-differences and charge-densities to be expected under the prevailing atmospheric conditions of the site, and desirable electrode resistance and capacities of the protectors installed.

此外，参考熟悉的尖头型避雷针，已被解释的事实的一个正确应用不仅证实了在我研发的改进后的避雷装置的理论适当性，而且将引导安装工程师正确认识那些条件，所说的条件取决于该建筑相对于周围地貌和其他建筑的位置、在现场的主要大气条件下预期的最大电位差和最大电荷密度的概率、以及所安装的避雷装置的所需电极的电阻和电容量。

The improved protector, as above stated, behaves in a manner just opposite to the Franklin type and is incomparably safer for this reason. The result is secured by the use of a terminal or conducting surface of large radius of curvature and sufficient area to make the density very small and thereby prevent the leakage of the charge and the ionization of the air. The device may be greatly varied in size and shape but it is essential that all its outer conducting elements should be disposed along an ideal enveloping surface of large radius and that they should have a considerable total area.

如上所述，改进后的保护器的行为方式与富兰克林型正好相反，因此也更加安全。通过使用具有大曲率半径和足够面积的一个终端或导电表面来确保该结果，以使电密度非常小，从而防止电荷泄漏和空气电离。该装置的尺寸和形状可以有很大的变化，但重要的是，其所有外部传导组件应该沿着大半径的理想包络面布置，并且它们应该具有相当大的总面积。

In Fig. 5, Fig. 6, Fig. 7 and Fig. 8, different kinds of such terminals and arrangements of same are illustrated. In Fig. 5, 12 is a cast or spun metal shell of ellipsoidal outlines, having on its under side a sleeve with a bushing 13 of porcelain or other insulating material, adapted to be slipped tightly on a rod 14, which may be an ordinary lightning conductor. Fig. 6 shows a terminal 15 made up of rounded or flat metal bars radiating from a central hub, which is supported directly on a similar rod and in electrical contact with the same. The special object of this type is to reduce the wind resistance, but it is essential that the bars have a sufficient area to insure small density, and also that they are close enough to make the aggregate capacity nearly equal to that of a continuous shell of the same outside dimensions. In Fig. 7 a cupola-shaped and earthed roof is carried by a chimney, serving in this way the twofold practical purpose of hood and protector. Any kind of metal may be used in its construction but it is indispensable that its outer surface should be free of sharp edges and projections from which streamers might emanate. In like manner mufflers, funnels and vents may be transformed into effective lightning protectors if equipped with suitable devices or designed in conformity with this invention. Still another modification is illustrated in Fig. 8 in which, instead of one, four grounded bars are provided with as many spun shells or attachments 18, with the obvious object of reducing the risk.

在图 5、6、7 和 8 中，展示了不同种类的这种终端及其布置。在图 5 中，12 是一个椭圆形轮廓的铸造的或旋压的金属壳，在其下侧具有带有陶瓷或其它绝缘材料的套管 13 的套筒，适于在杆 14 上紧紧地滑动，杆 14 可以是普通的避雷针。图 6 展示了由圆形或扁平金属条构成的终端 15，该金属条从中心毂辐射，该中心毂被直接支撑在类似的杆上并与其电接触。这种类型的特殊目的是减少风阻，但重要的是，条要有足够的面积以确保小的密度，并且它们要足够接近，以使总电容量几乎等于相同外部尺寸的连续壳体的总电容量。在图 7 中，一个圆顶形的接地屋顶由一个烟囱支撑，以这种方式实现了风帽和保护装置的双重实用目的。任何种类金属均可用于其构造，但其外表面必须没有可能发出流光的锐边和突出物，这一点是不可或缺的。以类似的方式，如果配备合适的装置或按照本发明设计，排气管消声器、烟囱和通风口可以转变成有效的避雷装置。图 8 中展示了另一种变型，在该图中，不是一个，而是四个接地条设置有同样多的旋压壳体或附件 18，明显的目的是降低风险。

From the foregoing it will be clear that in all cases the terminal prevents leakage of electricity and attendant ionization of the air. It is immaterial to this end whether it is insulated or not. Should it be struck the current will pass readily to the ground either directly or, as in Fig. 5, through a small air-gap between 12 and 14. But such an accident is rendered extremely improbable owing to the fact that there are everywhere points and projections on which the terrestrial charge attains a high density and where the air is ionized. Thus the action of the improved protector is equivalent to a repellent force. This being so, it is not necessary to support it at a great height, but the ground connection should be made with the usual care and the conductor leading to it must be of as small a self-induction and resistance as practicable.

从前述内容可以清楚地看出，在所有情况下，终端都防止漏电和伴随的空气电离。它是否绝缘并不重要。如果被击中，电流将直接传导到地面或如图 5 所示通过 12 和 14 之间的一个小气隙容易地传导到地面。但这样的事故是非常不可能的，因为事实上到处都有地面电荷达到高密度的尖头和突起，在那里空气被电离。因此，改进后的保护器的作用相当于一个排斥力。既然如此，就没有必要将它支撑在很高的高度，但是接地连接应该小心进行，并且通向接地连接的导体必须具有尽可能小的自感和电阻。

I claim as my invention:

我主张是我的发明是：

1. A lightning protector consisting of an elevated terminal, having its outer conducting boundaries arranged on surfaces of large radii of curvature in both dimensions, and a grounded conductor of small self-induction, as set forth.

1、一种避雷装置，包括一个高架终端，其外部导电边界被布置在两个维度的大曲率半径表面上，还有一个小自感的接地导体，如前所述。

2. A lightning protector composed of a metallic shell of large radius of curvature, and a grounded conductor of small self-induction, as described.

2、由大曲率半径的金属外壳和小自感的接地导体组成的一种避雷装置，如上所述。

3. Apparatus for protection against atmospheric discharges comprising an earth connection of small resistance, a conductor of small self-induction and a terminal carried by the same and having a large radius of curvature in two dimensions as, and for the purpose set forth.

3、用于防止大气放电的装置，包括一个小电阻的接地连接、一个小自感的导体和由该导体承载的终端，该终端并且具有大的二维曲率半径，用于所述目的。

4. In apparatus for protection against atmospheric discharges an insulated metallic shell of large radius of curvature supported by a grounded conductor and separated from the same through a small air-gap as, and for the purpose described.

4、在防止大气放电的装置中，一个大曲率半径的绝缘金属壳由一个接地导体支撑，并通过一个小的气隙与接地导体分开，并用于所述目的。

5. A lightning protector comprising, in combination, an elevated terminal of large area and radius of curvature in two dimensions, and a grounded conductor of small self-induction, as set forth.

5、一种避雷装置，包括具有大面积和二维曲率半径的高架终端，还有小自感的接地导体，如上所述。

6. In apparatus for protection against lightning discharges, the combination of an elevated metallic roof of large area and radius of curvature in two dimensions, and a grounded conductor of small self-induction and resistance, as described.

6、在用于防止雷电放电的装置中，存在一个大面积的和二维曲率半径的高架金属屋顶与小的自感和电阻的接地导体的组合，如上所述。

7. As an article of manufacture a metallic shell of large radius of curvature provided with a sleeve adapted for attachment to a lightning rod as, and for the purpose set forth.

7、作为一种制造物品，一种具有大曲率半径的金属外壳，它配有适于连接到避雷针的一个套管，并用于所述目的。

8. A lightning protector comprising an ellipsoidal metallic shell and a grounded conductor of small self-induction, as set forth.

8、一种避雷装置，包括椭圆形金属外壳和小自感的接地导体，如前所述。

9. In apparatus for protection against atmospheric discharges a cupola-shaped metallic terminal of smooth outer surface, in combination with a grounded conductor of small self-induction and resistance, as described.

9、在防止大气放电的装置中，光滑外表面的圆顶形金属终端与小的自感和电阻的接地导体相结合，如上所述。

In testimony whereof I affix my signature.
我签名为证。

NIKOLA TESLA.
尼古拉·特斯拉

N. TESLA.
LIGHTNING PROTECTOR.
APPLICATION FILED MAY 6, 1916.

1,266,175.

Patented May 14, 1918.

Fig. 1.

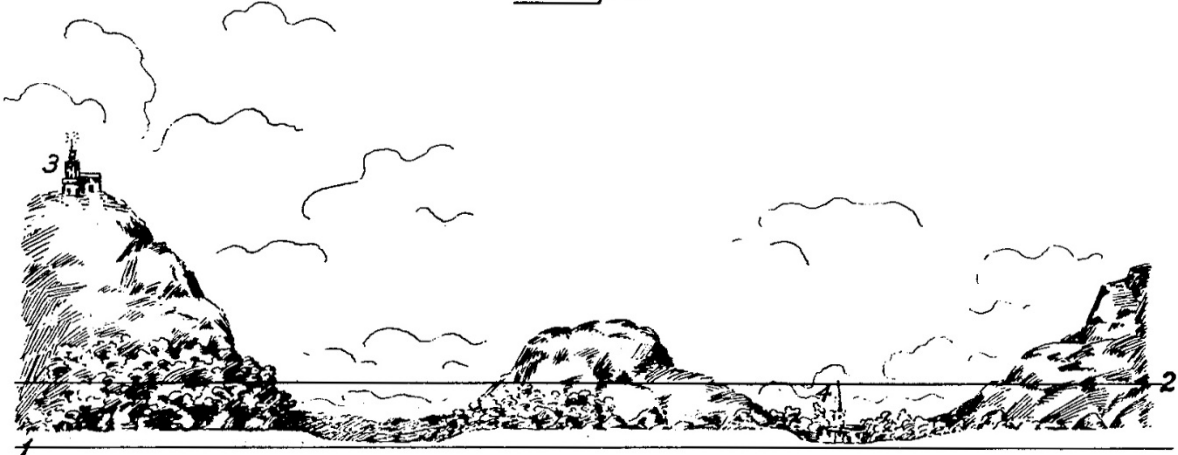


Fig. 3.

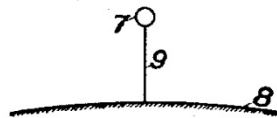


Fig. 2.



Fig. 4.

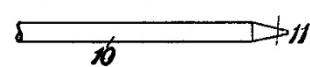


Fig. 5.

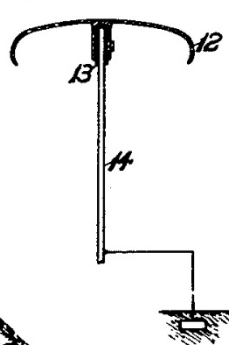


Fig. 6.

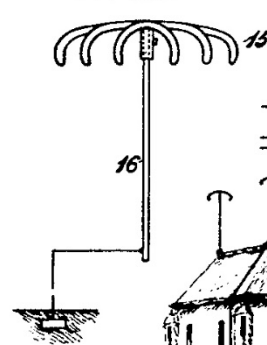
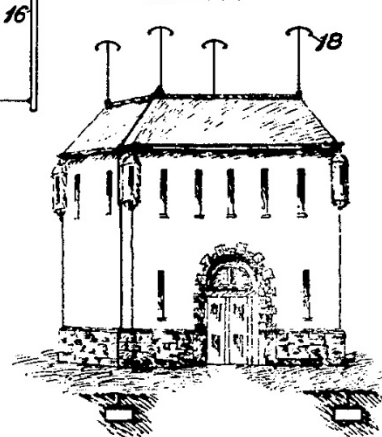


Fig. 7.



Fig. 8.



WITNESSES:

John B. Milgum
William Johnson

INVENTOR.

Nikola Tesla

BY
Kerr, Page, Cooper & Hayward
ATTORNEYS

COIL FOR ELECTRO-MAGNETS.

电磁线圈

NIKOLA TESLA, OF NEW YORK, N. Y.

纽约州纽约市的尼古拉·特斯拉

SPECIFICATION forming part of Letters Patent No. 512,340, dated January 9, 1894.

Application filed July 7, 1893. Serial No. 479,804. (No model.)

该说明书形成了颁发于 1894 年 1 月 9 日编号为 512,340 的专利证书的一部分。

申请于 1893 年 7 月 7 日提交。序列号为 479,804。(没有模型)

To all whom it may concern:

致所有相关人士:

Be it known that I, NIKOLA TESLA, a citizen of the United States, residing at New York, in the county and State of New York, have invented certain new and useful Improvements in Coils for Electro-Magnets and other Apparatus, of which the following is a specification, reference being had to the drawings accompanying and forming a part of the same.

众所周知，我、尼古拉·特斯拉，来自奥匈帝国边境地区的利卡县的史密里安村，居住在纽约州的纽约市，在电磁线圈方面已经发明了某些新的和有用的改进，以下是该发明一个说明书，必须参考随附的图纸，它已形成了该说明书的一部分。

In electric apparatus or systems in which alternating currents are employed the self-induction of the coils or conductors may, and, in fact, in many cases does operate disadvantageously by giving rise to false currents which often reduce what is known as the commercial efficiency of the apparatus composing the system or operate detrimentally in other respects. The effects of self-induction, above referred to, are known to be neutralized by proportioning to a proper degree the capacity of the circuit with relation to the self-induction and frequency of the currents. This has been accomplished heretofore by the use of condensers constructed and applied as separate instruments.

在使用交流电的电气设备或系统中，线圈或导体的自感可能并且事实上在许多情况下确实会由于产生错误的电流而不利地工作，错误电流通常会降低组成系统的设备的商业效率，或者在其他方面对设备有害。上面提到的自感效应，已知可以通过将电路容量与自感和电流频率成适当的比例来抵消。迄今为止，这是通过使用作为独立仪器来构建的和应用的电容器来实现的。

My present invention has for its object to avoid the employment of condensers which are expensive, cumbersome and difficult to maintain in perfect condition, and to so construct the coils themselves as to accomplish the same ultimate object.

我的本发明旨在避免使用昂贵、笨重且难以保持完美状态的电容器，并构建线圈本身以实现相同的最终目的。

I would here state that by the term coils I desire to include generally helices, solenoids, or, in fact, any conductor the different parts of which by the requirements of its application or use are brought into such relations with each other as to materially increase the self-induction.

我在这里声明，我希望术语“线圈”包括一般的螺旋线、螺线管、或者事实上的任何导体，导体的不同部分根据其应用或使用的要求建立相互关系，从而实质性地增加自感。

I have found that in every coil there exists a certain relation between its self-induction and capacity that permits a current of given frequency and potential to pass through it with no other opposition than that of ohmic resistance, or, in other words, as though it possessed no self-induction. This is due to the mutual relations existing between the special character of the current and the self-induction and capacity of the coil, the latter quantity being just capable of neutralizing the self-induction for that frequency. It is well-known that the higher the frequency or potential difference of the current the smaller the capacity required to counteract the self-induction; hence, in any coil, however small the capacity, it may be sufficient for the purpose stated if the proper conditions in other respects be secured. In the ordinary coils the difference of potential between adjacent turns or spires is very small, so that while they are in a sense condensers, they possess but very small capacity and the relations between the two quantities, self-induction and capacity, are not such as under any ordinary conditions satisfy the requirements herein contemplated, because the capacity relatively to the self-induction is very small.

我发现在每个线圈中在自感和电容量之间存在某种关系，这种关系允许具有一个给定频率和给定电势的电流在通过它时除了遇到欧姆电阻外，没有其他阻力，或者，换句话说，好像它没有自感。这是由于电流的特殊性质与线圈的自感和电容量之间存在的相互关系，后者的量刚好能够抵消该频率的自感。众所周知，电流的频率或电位差越高，抵消自感所需的电容量就越小；因此，在任何线圈中，无论电容量多么小，如果在其他方面保证了适当的条件，就足以满足所述的目的。在普通线圈中，相邻匝圈或相邻螺旋之间的电势差非常小，因此虽然它们在某种意义上是电容器，但是它们的电容量非常小，并且自感和电容量这两个量之间的关系在任何普通条件下都不满足这里预期的要求，因为相对于自感来说电容量非常小。

In order to attain my object and to properly increase the capacity of any given coil, I wind it in such way as to secure a greater difference of potential between its adjacent turns or convolutions, and since the energy stored in the coil—considering the latter as a condenser, is proportionate to the square of the potential difference between its adjacent convolutions, it is evident that I may in this way secure by a proper disposition of these convolutions a greatly increased capacity for a given increase in potential difference between the turns.

为了达到我的目的，并适当地增加任何给定线圈的电容量，我以这样的方式缠绕它，以确保其相邻的匝圈之间的电位差更大，并且由于存储在线圈中的能量（将线圈视为一种电容器）与它的相邻匝圈之间的电位差的平方成正比例，很明显，我可以用这种方式通过这些匝圈的适当布置来确保极大增加的电容量，用于匝圈之间的电位差的一个给定的提高。

I have illustrated diagrammatically in the accompanying drawings the general nature of the plan which

I adopt for carrying out this invention.

我已经在附图中示意性地说明了我采用的实施本发明的方案的一般性质。

Figure 1 is a diagram of a coil wound in the ordinary manner. Fig. 2 is a diagram of a winding designed to secure the objects of my invention.

图 1 是以普通方式缠绕的线圈的示意图。图 2 是设计用于确保我的发明的目的的绕组的示意图。

Let A, Fig. 1, designate any given coil the spires or convolutions of which are wound upon and insulated from each other. Let it be assumed that the terminals of this coil show a potential difference of one hundred volts, and that there are one thousand convolutions; then considering any two contiguous points on adjacent convolutions let it be assumed that there will exist between them a potential difference of one-tenth of a volt. If now, as shown in Fig. 2, a conductor B be wound parallel with the conductor A and insulated from it, and the end of A be connected with the starting point of B, the aggregate length of the two conductors being such that the assumed number of convolutions or turns is the same, viz., one thousand, then the potential difference between any two adjacent points in A and B will be fifty volts, and as the capacity effect is proportionate to the square of this difference, the energy stored in the coil as a whole will now be two hundred and fifty thousand as great. Following out this principle, I may wind any given coil either in whole or in part, not only in the specific manner herein illustrated, but in a great variety of ways, well-known in the art, so as to secure between adjacent convolutions such potential difference as will give the proper capacity to neutralize the self-induction for any given current that may be employed. Capacity secured in this particular way possesses an additional advantage in that it is evenly distributed, a consideration of the greatest importance in many cases, and the results, both as to efficiency and economy, are the more readily and easily obtained as the size of the coils, the potential difference, or frequency of the currents are increased.

设图 1 中的 A 表示任何给定的螺旋，其螺旋或匝圈缠绕在一起并彼此绝缘。假设这个线圈的两个终端有一百伏的电位差，并且有一千匝；然后考虑相邻匝圈上的任何两个相邻点，假设它们之间存在十分之一伏特的电位差。现在，如图 2 所示，导体 B 平行于导体 A 被缠绕并与 A 绝缘，A 的末端与 B 的起点相连，两个导体的总长度是这样的，即假设的盘旋数或匝数是相同的，即 1000 圈，那么在 A 和 B 中的任何两个相邻点之间的电势差将是五十伏特，并且由于电容效应与这个差的平方成正比例，存储在整个线圈中的能量现在将是二十五万。遵循这一原理，我可以全部地或部分地缠绕任何给定的线圈，不仅以这里所示的特定方式，而且以本领域众所周知的多种方式，以便在相邻匝圈之间确保这样的电势差，该电势差将给出适当的电容量来抵消可以采用的任何给定电流的自感。以这种特定方式获得的电容量具有额外的优点，因为它是均匀分布的，这在许多情况下是最重要的考虑因素，并且随着线圈尺寸、电势差或电流频率的增加，效率和经济性方面的结果将更容易获得。

Coils composed of independent strands or conductors wound side by side and connected in series are not in themselves new, and I do not regard a more detailed description of the same necessary. But heretofore, so far as I am aware, the objects in view have been essentially different from mine, and the results which I obtain even if an incident to such forms of winding have not been appreciated or taken advantage of.

由独立股线或独立导体并排缠绕并且串联而成的线圈本身并不新颖,我认为没有必要对其进行更详细的描述。但到目前为止,据我所知,所看到的物体与我的有着本质的不同,即使发生这种形式的缠绕,我所获得的结果也没有被理解或利用。

In carrying out my invention it is to be observed that certain facts are well understood by those skilled in the art, viz.: the relations of capacity, self-induction, and the frequency and potential difference of the current. What capacity, therefore, in any given case it is desirable to obtain and what special winding will secure it, are readily determinable from the other factors which are known.

在实施我的发明时,应当观察到某些事实是本领域技术人员所熟知的,即:电容、自感以及电流频率和电位差之间的关系。因此,在任何给定的情况下,希望获得什么样的电容量,以及将使用什么样的特殊绕组将确保它,这些都可以从已知的其他因素中轻松地确定。

What I claim as my invention is—

我主张我的发明是—

1. A coil for electric apparatus the adjacent convolutions of which form parts of the circuit between which there exists a potential difference sufficient to secure in the coil a capacity capable of neutralizing its self-induction, as hereinbefore described.

1、一种用于电气装置的线圈,其相邻匝圈形成电路的多个部分,相邻匝圈间存在电势差,足以保证线圈具有能够抵消其自感的电容量,如上所述。

2. A coil composed of contiguous or adjacent insulated conductors electrically connected in series and having a potential difference of such value as to give to the coil as a whole, a capacity sufficient to neutralize its self-induction, as set forth.

2、由连续或相邻的被绝缘导体串联而成的线圈,其电位差足以使线圈整体具有足以抵消其自感的电容量,如前所述。

NIKOLA TESLA.

尼古拉·特斯拉

Witnesses:

ROBT. F. GAYLORD,

PARKER W. PAGE.

见证人:

罗伯特·F·盖洛德、帕克·W·佩奇。

(No Model.)

N. TESLA.
COIL FOR ELECTRO MAGNETS.

No. 512,340.

Patented Jan. 9, 1894.

Fig. 1

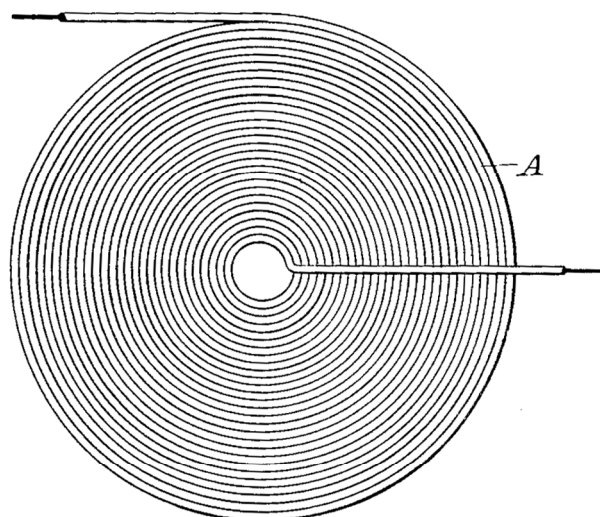
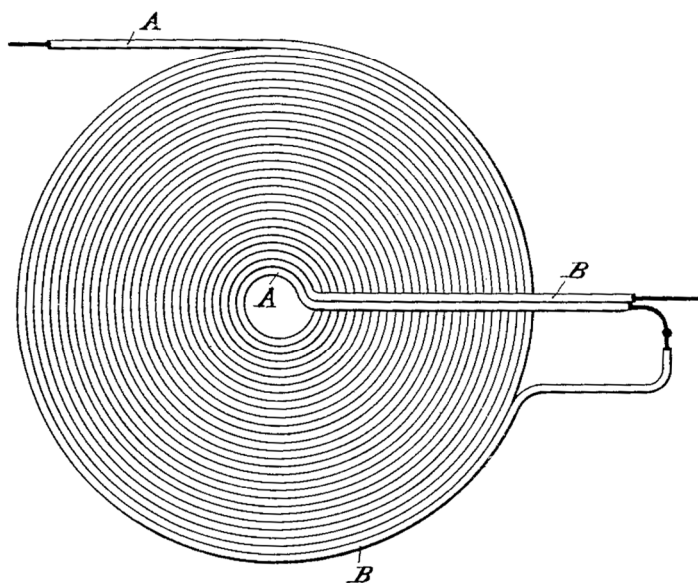


Fig. 2



Witnesses
Raphael Nitter
James M. Galtner

Inventor
Nikola Tesla
By his Attorneys
Duncan & Page

ELECTRIC-RAILWAY SYSTEM.

电力铁路系统

NIKOLA TESLA, OF NEW YORK, N. Y.

纽约州纽约市的尼古拉·特斯拉

SPECIFICATION forming part of Letters Patent No. 514,972, dated February 20, 1894.

Application filed January 2, 1892. Serial No. 416,774. (No model.)

该说明书形成了颁发于 1894 年 2 月 20 日编号为 514,972 的专利证书的一部分。

申请于 1892 年 1 月 2 日提交。序列号为 416,774。(没有模型)

To all whom it may concern:

致所有相关人士:

Be it known that I, NIKOLA TESLA, a citizen of the United States, residing at New York, in the county and State of New York, have invented certain new and useful Improvements in Electric-Railway Systems, of which the following is a specification, reference being had to the drawings accompanying and forming a part of the same.

众所周知，我、尼古拉·特斯拉，一位美国公民，现在居住在纽约州纽约郡纽约市，在电力铁路系统方面已经发明了某些新的和有用的改进，以下是该发明一个说明书，必须参考随附的图纸，它已形成该说明书的一部分。

This invention is an improved system or plan of supplying electric current to the motors of street or other cars or vehicles from a central or stationary source of supply, without the use of sliding or rolling contacts between the line conductor and the car motors. I use in my system alternating or pulsating currents of very high potential, and, by reason mainly of the higher economy, high frequency. The conductor which conveys these currents is run from the stationary source of supply along the line of travel and preferably through a conduit constructed between, or alongside of the tracks or rails.

本发明是一种从中央电源或固定电源向街道或其他汽车或车辆的电动机提供电流的改进后的系统或方案，在线路导体和汽车电动机之间不使用滑动接触或滚动接触。我在我的系统中使用具有甚高电势的交流电流或脉冲电流，主要是因为更高的经济性和高频率。传送这些电流的导体从固定电源沿着行进路线延伸，并且首选地穿过在铁轨与铁轨之间或铁轨旁边构造的一根导管。

To prevent the dissipation of the electric energy that would otherwise occur on a circuit conveying currents of the character which I use, I insulate the line conductor and surround it with a conducting coating that serves as a screen, and I prefer, mainly with the object of localizing the action that would result from the establishment of an electrical connection between the screen and the ground or other conducting body, to divide up the outer conductor into insulated sections of comparatively short length.

In the car, or to each of a number running on a given track, equipped in accordance with my invention, I attach an arm carrying a conducting plate or bar that is electrically connected with the motor coils and which by the movement of the car is carried in proximity to the line conductor, so as to take off, by condenser action, sufficient energy to run the car motor.

为了防止在传输我所使用的具有该特性的电流的电路上发生电能耗散, 我将线路导体绝缘并用充当屏蔽的一个导电涂层围绕它, 我倾向于将外导体分成长度相对较短的被绝缘部分, 主要目的是将屏蔽与地面或其他导体之间建立的电连接所产生的作用局限于局部。在根据我的发明来装备的轿厢中, 或者在给定轨道上运行的多个轿厢中的每一个上, 我安装了一个带有导电板或导电条的臂, 该导电板或导电条与电动机线圈电连接, 并且通过轿厢的运动, 该导电板或导电条被带到线路导体附近, 以便通过电容器的作用获取足够的能量来运行轿厢电动机。

The details of the invention, and the best manner I am aware of in which it is or may be carried out, I shall explain by reference to the accompanying drawings.

本发明的细节, 以及我所知道的实施或可能实施的最佳方式, 我将参照附图进行解释。

Figure 1 is a view showing a portion of a car and the means for supplying the motor of the same with current from a line conductor supported within a conduit between the rails. Fig. 2 is an enlarged sectional view of the arm carrying the conductor through which the electric energy is transmitted from the line conductor to the motor. Fig. 3 is an enlarged view partly in section of the line conductor.

图 1 是展示了一个轿厢的一部分和用于从被支撑在轨道之间的导管内的线路导体向轿厢的电动机供电的装置的视图。图 2 是携带导体的臂的放大剖视图, 电能通过该导体从线路导体传输到电动机。图 3 是线路导体的部分截面放大图。

I propose to employ an iron conduit A, which is buried preferably between the rails of the track and provided with a longitudinal slot along its top close to one edge or side. A flange B is formed or applied along the slot, forming a protected chamber or compartment for containing the line conductor. This chamber should be of such form in cross-section that its walls will be symmetrically disposed with respect to the conductor running through it, and thus reduce to a minimum any disturbing inductive effects which would be produced by an unsymmetrical disposition of the walls with respect to the conducting screen or covering around the conductor.

我建议使用一个铁管 A, 它最好埋在轨道的铁轨之间, 并沿其铁轨顶部靠近一边或一侧设有一个纵向槽。沿着该槽形成或应用一个凸缘 B, 形成用于容纳线路导体的受保护的腔室或隔间。该腔室的横截面形状应使其壁相对于穿过它的导体对称设置, 从而将由壁相对于导体周围的导电屏蔽或覆盖物的不对称布置所产生的任何干扰感应效应降至最低。

For the line conductor I employ a suitable wire C, surrounded by an insulated coating D, which is enclosed in a metallic sheathing G. For the latter I prefer to use iron pipes provided with perforated lugs F, by means of which the conductor is suspended by insulated rods or other devices E. I also divide up the conducting screen or sheathing into sections insulated from one another, but overlapping so as to leave no breaks in the screen. The advantage in dividing up the screen in this manner is that the loss

due to currents induced in the outer conductor is reduced, while at the same time the grounding of any one section would result in a very small loss compared with what would take place from a continuous sheath; moreover, by overlapping the ends of the sections but little opportunity is afforded for the dissipation of energy.

对于线路导体，我采用了一条适合的导线 C，由绝缘涂层 D 包围，该涂层被封装在金属护套 G 中。对于后者，我倾向于使用配有穿孔线耳 F 的铁管，通过该线耳，导体由被绝缘的条或其他装置 E 悬挂。我还将导电屏蔽或护套分割成彼此绝缘的部分，但相互重叠，以便在屏蔽中不留任何中断。以这种方式分割屏蔽的优点在于，由于在外导体中被感应出的电流所导致的损耗减少，同时与一个连续护套相比，任何一个部分的接地将导致非常小的损耗；此外，通过重叠各部分的端部，只有一点点机会耗散能量。

The car is represented as carrying a motor H, which may be of any suitable construction and capable of being operated by currents of the kind employed. Connected with the motor or car is an iron or conducting tube I, that extends down into the conduits through the slots therein. The lower end of this tube is bent in the form of a hook and supports within the conductor chamber a bar or plate J that presents to the line conductor a conducting surface. This bar or plate is electrically connected with the motor coils by an insulated wire K, that passes up through the tube I, and all parts of the said plate except the surface exposed to the conductor C, or its metallic sheath, are insulated and protected by a metallic screen L. It is obvious that all portions of the arm as well as the plate itself may be insulated as by a water-proof covering, and it will be understood that the principal object of the invention would still be attained even though the plate were in actual contact with the screen while the car is in motion.

轿厢被表示为承载着一个电动机 H，它可以是任何合适的结构，并且能够由所采用的电流种类来运行。与电动机或轿厢相连的是一根铁管或导管 I，它通过导管中的槽向下延伸到导管中。该管的下端弯曲成钩形，并在导体室内支撑一个条或板 J，该条或板 J 为线路导体提供一个导电表面。该条或板通过一条绝缘线 K 与电动机线圈电连接，该绝缘线 K 向上穿过管 I，并且除了暴露于导体 C 的表面或其金属护套之外，所述板的所有部分都由金属屏蔽层 L 绝缘和保护。很明显，臂的所有部分以及板本身可以通过防水覆盖物绝缘，并且可以理解的是，即使在轿厢运动时板也是与屏蔽实际接触的，本发明的主要目的仍然可以实现。

In operation, the line conductor C is connected with a source of current of very high potential and great frequency. This current may be conveyed to any desired distance without material loss, as the insulated metallic covering or sheath around the conductor serves as a static screen to prevent the dissipation of the energy. The presence, however, of a plate J of any car close to the sheath or screen disturbs the electrical equilibrium and sets up by condenser action a transfer of energy from the screen to the plate sufficient to operate the motor on the car.

在运行中，线路导体 C 与甚高电位和甚高频率的电流源连接。这种电流可以传输到任何需要的距离，而没有材料损失，因为导体周围的绝缘金属覆盖层或护套起到了防止能量耗散的静态屏蔽的作用。然而，靠近护套或屏蔽的任何轿厢的板 J 的存在扰乱了电平衡，并通过电容器作用建立了从屏蔽到板的能量传递，足以运行轿厢上的电动机。

In the above, I have described the screen, whether continuous or subdivided, as wholly insulated from the ground or surrounding conducting bodies, but the single continuous screen or each section of the

same, may be connected to the ground through a condenser of relatively very small capacity, through a device of high self-induction or resistance, as shown in dotted lines at C' in Fig. 1.

在上文中,我已经描述了屏蔽,无论是连续的还是细分的,都与地面或周围的导体完全绝缘,但是单个连续屏蔽或屏蔽的每个部分可以通过容量相对非常小的电容器、通过高自感应或高电阻的装置连接到地,如图1中C'处的虚线所示。

I do not claim in this application the particular line conductor described, nor the broad idea of inducing from a stationary conductor the current to operate the motor on a traveling car or other vehicle, but

在本申请中,我没有主张所描述的特定线路导体,也没有主张来自一个静止导体的施感电流以运行行驶一辆轿厢或其他车辆上的电动机的宽泛概念,但是

What I claim is—

我主张的是—

1. In an electric railroad system operated by electric currents of high potential and frequency, the combination of an insulated and electrically screened supply conductor extending along the line of travel, a motor car or cars carrying a conducting plate or bar in inductive relation to the screened conductor and an electrical connection between the said plate and the motor, as set forth.

1、在由高电势和高频率的电流运行的电力铁路系统中,存在一个组合,包括:沿着行进路线延伸的被绝缘且被电屏蔽的供电导体;一个或多个电动机轿厢,携带着与被屏蔽导体成感应关系的导电板或导电条;以及所述导电板和电动机之间的电连接,如前所述。

2. In an electric railroad system operated by electric currents of high potential and frequency, the combination of a supply conductor running along the line of travel, a conducting sheath or screen divided into insulated sections and surrounding the said conductor, a motor car supporting a conducting body in proximity to the supply conductor and an electrical connection between said body and the motor as set forth.

2、在由高电势和高频率的电流运行的电力铁路系统中,存在一个组合,包括:沿着行进路线延伸的供电导体;被分割成多个被绝缘部分并包围所述导体的导电护套或屏蔽;在供电导体附近支撑着导体的电动机轿厢以及所述导体和电动机之间的电连接,如前所述。

3. In an electrical railway system, the combination with a slotted conduit of an insulated conductor supported therein, an insulated sheath or screen surrounding the conductor, a motor car adapted to run on tracks parallel with the conduit, a conducting plate or bar carried by an arm descending from the car into the conduit, and an electrical connection between the plate and the motor, as set forth.

3、在由高电势和高频率的电流运行的电力铁路系统中,存在一个组合,包括:一个被绝缘导体的一个开槽导管,该导体从内部被支撑;围绕导体的一个绝缘护套或屏蔽;适于在平行于导管的轨道上行驶的一个电动机轿厢;由从轿厢下降到导管中的臂所携带的导电板或导电条以及板和电动机之间的电连接,如前所述。

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(No Model.)

N. TESLA.
ELECTRIC RAILWAY SYSTEM.

No. 514,972.

Patented Feb. 20, 1894.

Fig. 1

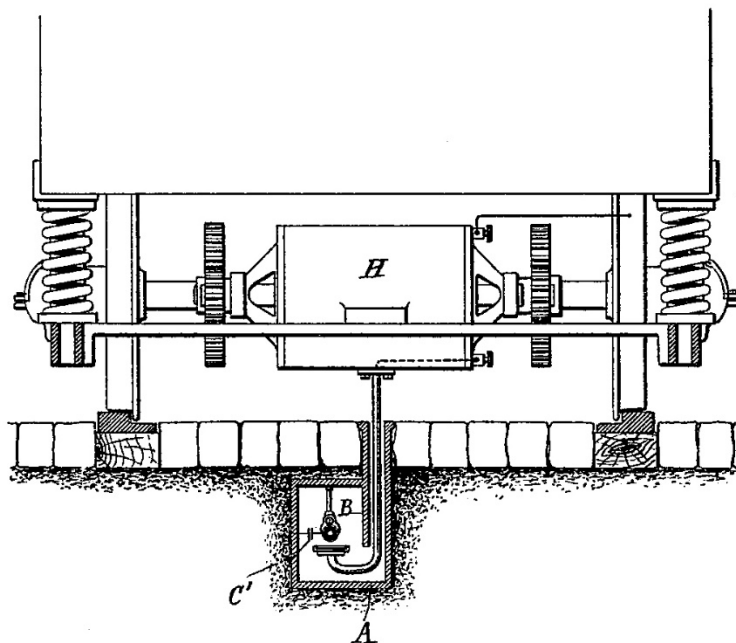


Fig. 2

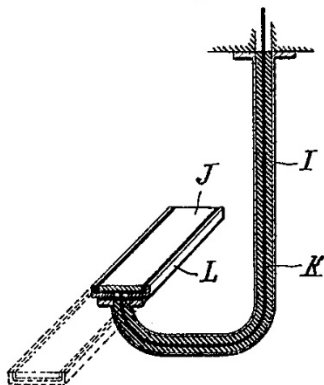
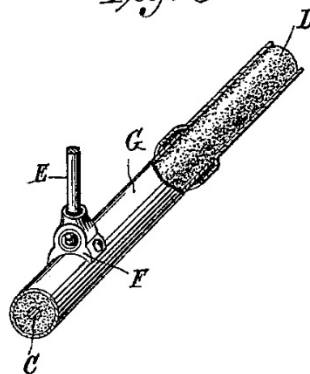


Fig. 3



Witnesses:

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